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Patentanmeldung Nr. Patent application No. Demande de brevet n°

03006254.1

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(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
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Substituted piperidine and piperazine derivatives as melanocortin-4 Receptor
modulators

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Substituted Piperidine and Piperazine Derivatives as Melanocortin-4 Réceptor Modulators

20. März 2003

Field of the Invention

The present invention relates to novel substituted piperidine and piperazine derivatives as melanocortin-4 receptor modulators. Depending on the structure and the stereochemistry the compounds of the invention are either selective agonists or selective antagonists of the human melanocortin-4 receptor (MC-4R). The agonists can be used for the treatment of disorders and diseases such as obesity, diabetes and sexual dysfunction, whereas the antagonists are useful for the treatment of disorders and diseases such as cancer cachexia, muscle wasting, anorexia, anxiety and depression. Generally all diseases and disorders where the regulation of the MC-4R is involved can be treated with the compounds of the invention.

Background of the Invention

Melanocortins (MCs) stem from pro-opiomelanocortin (POMC) via proteolytic cleavage. These peptides, adrenocorticotrophic hormone (ACTH), α -melanocyte-stimulating hormone (α -MSH), β -MSH and γ -MSH, range in size from 12 to 39 amino acids. The most important endogenous agonist for central MC-4R activation appears to be the tridecapeptide α -MSH. Among MCs, it was reported that α -MSH acts as a neurotransmitter or neuromodulator in the brain. MC peptides, particularly α -MSH, have a wide range of effects on biological functions including feeding behavior, pigmentation and exocrine function. The biological effects of α -MSH are mediated by a sub-family of 7-transmembrane G-protein-coupled receptors, termed melanocortin receptors (MC-Rs). Activation of any of these MC-Rs results in stimulation of cAMP formation.

To date, five distinct types of receptor subtype for MC (MC-1R to MC-5R) have been identified and these are expressed in different tissues.

MC-1R was first found in melanocytes. Naturally occurring inactive variants of MC-1R in animals were shown to lead to alterations in pigmentation and a subsequent lighter coat color by controlling the conversion of pheomelanin to eumelanin through the control of

tyrosinase. From these and other studies, it is evident that MC-1R is an important regulator of melanin production and coat color in animals and skin color in humans.

The MC-2R is expressed in the adrenal gland representing the ACTH receptor. The MC-2R is not a receptor for α -MSH but is the receptor for the adrenocorticotrophic hormone I (ACTH I).

The MC-3R is expressed in the brain (predominately located in the hypothalamus) and peripheral tissues like gut and placenta, and knock-out studies have revealed that the MC-3R may be responsible for alterations in feeding behavior, body weight and thermogenesis.

The MC-4R is primarily expressed in the brain. Overwhelming data support the role of MC-4R in energy homeostasis. Genetic knock-outs and pharmacologic manipulation of MC-4R in animals have shown that agonizing the MC-4R causes weight loss and antagonizing the MC-4R produces weight gain (A. Kask, et al., "Selective antagonist for the melanocortin-4 receptor (HS014) increases food intake in free-feeding rats," *Biochem. Biophys. Res. Commun.*, 245: 90-93 (1998)).

MC-5R is ubiquitously expressed in many peripheral tissues including white fat, placenta and a low level of expression is also observed in the brain. However its expression is greatest in exocrine glands. Genetic knock-out of this receptor in mice results in altered regulation of exocrine gland function, leading to changes in water repulsion and thermoregulation. MC-5R knockout mice also reveal reduced sebaceous gland lipid production (Chen et al., *Cell*, 91: 789-798 (1997)).

Attention has been focused on the study of MC-3R and MC-4R modulators and their use in treating body weight disorders, such as obesity and anorexia. However, evidence has shown that the MC peptides have potent physiological effects besides their role in regulating pigmentation, feeding behavior and exocrine function. In particular, α -MSH recently has been shown to induce a potent anti-inflammatory effect in both acute and chronic models of inflammation including inflammatory bowel-disease, renal ischemia/reperfusion injury and endotoxin-induced hepatitis. Administration of α -MSH in these models results in substantial

reduction of inflammation-mediated tissue damage, a significant decrease in leukocyte infiltration and a dramatic reduction in elevated levels of cytokines and other mediators to near baseline levels. Recent studies have demonstrated that the anti-inflammatory actions of α -MSH are mediated by MC-1R. The mechanism by which agonism of MC-1R results in an anti-inflammatory response is likely through inhibition of the pro-inflammatory transcription activator, NF- κ B. NF- κ B is a pivotal component of the pro-inflammatory cascade, and its activation is a central event in initiating many inflammatory diseases. Additionally, anti-inflammatory actions of α -MSH may be, in part, mediated by agonism of MC-3R and/or MC-5R.

A specific single MC-R that may be targeted for the control of obesity has not yet been identified, although evidence has been presented that MC-4R signaling is important in mediating feeding behavior (S.Q. Giraudo et al., "Feeding effects of hypothalamic injection of melanocortin-4 receptor ligands," *Brain Research*, 80: 302-306 (1998)). Further evidence for the involvement of MC-Rs in obesity includes: a) the agouti (A^y) mouse which ectopically expresses an antagonist of the MC-1R, MC-3R and MC-4R is obese, indicating that blocking the action of these three MC-R's can lead to hyperphagia and metabolic disorders; 2) MC-4R knockout mice (D. Huszar et al., *Cell*, 88: 131-141 (1997)) recapitulate the phenotype of the agouti mouse and these mice are obese; 3) the cyclic heptapeptide melanotanin II (MT-II) (a non-selective MC-1R, -3R, -4R, and -5R agonist) injected intracerebroventricularly (ICV) in rodents, reduces food intake in several animal feeding models (NPY, ob/ob, agouti, fasted) while ICV injected SHU-9119 (MC-3R and 4R antagonist; MC-1R and -5R agonist) reverses this effect and can induce hyperphagia; 4) chronic intraperitoneal treatment of Zucker fatty rats with an α -NDP-MSH derivative (HP-228) has been reported to activate MC-1R, -3R, -4R, and -5R and to attenuate food intake and body weight gain over a 12 week period (I. Corcos et al., "HP-228 is a potent agonist of melanocortin receptor-4 and significantly attenuates obesity and diabetes in Zucker fatty rats," *Society for Neuroscience Abstracts*, 23: 673 (1997)).

MC-4R appears to play a role in other physiological functions as well, namely controlling grooming behavior, erection and blood pressure. Erectile dysfunction denotes the medical condition of inability to achieve penile erection sufficient for successful intercourse. The term "impotence" is often employed to describe this prevalent condition. Synthetic melanocortin

receptor agonists have been found to initiate erections in men with psychogenic erectile dysfunction. (H. Wessells et al., "Synthetic Melanotropic Peptide Initiates Erections in Men With Psychogenic Erectile Dysfunction: Double-Blind, Placebo Controlled Crossover Study," J. Urol., 160: 389-393, 1998). Activation of melanocortin receptors of the brain appears to cause normal stimulation of sexual arousal. Evidence for the involvement of MC-R in male and/or female sexual dysfunction is detailed in WO/0074679.

Diabetes is a disease in which a mammal's ability to regulate glucose levels in the blood is impaired because the mammal has a reduced ability to convert glucose to glycogen for storage in muscle and liver cells. In Type I diabetes, this reduced ability to store glucose is caused by reduced insulin production. "Type II diabetes" or "Non-Insulin Dependent Diabetes Mellitus" (NIDDM) is the form of diabetes which is due to a profound resistance to insulin stimulating or regulatory effect on glucose and lipid metabolism in the main insulin-sensitive tissues, muscle, liver and adipose tissue. This resistance to insulin responsiveness results in insufficient insulin activation of glucose uptake, oxidation and storage in muscle, and inadequate insulin repression of lipolysis in adipose tissue and of glucose production and secretion in liver. When these cells become desensitized to insulin, the body tries to compensate by producing abnormally high levels of insulin and hyperinsulemia results. Hyperinsulemia is associated with hypertension and elevated body weight. Since insulin is involved in promoting the cellular uptake of glucose, amino acids and triglycerides from the blood by insulin sensitive cells, insulin insensitivity can result in elevated levels of triglycerides and LDL which are risk factors in cardiovascular diseases. The constellation of symptoms which includes hyperinsulemia combined with hypertension, elevated body weight, elevated triglycerides and elevated LDL, is known as Syndrome X. MC-4R agonists might be useful in the treatment of NIDDM and Syndrome X.

Among MC receptor subtypes, the MC4 receptor is also of interest in terms of the relationship to stress and the regulation of emotional behavior, as based on the following findings. Stress initiates a complex cascade of responses that include endocrine, biochemical and behavioral events. Many of these responses are initiated by release of corticotropin-releasing factor (CRF) (Owen MJ and Nemeroff CB (1991) Physiology and pharmacology of corticotrophin releasing factor. *Pharmacol Rev* 43:425-473). In addition to activation of the brain CRF system, there are several lines of evidence that melanocortins

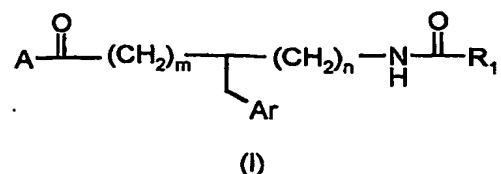
(MCs), which stem from proopiomelanocortin by enzymatic processing, mediate important behavioral and biochemical responses to stress and, consequently, stress-induced disorders like anxiety and depression (Anxiolytic-Like and Antidepressant-Like Activities of MCL0129 (1-[(S)-2-(4-Fluorophenyl)-2-(4-isopropylpiperidin-1-yl)ethyl]-4-[4-(2-methoxynaphthalen-1-yl)butyl]piperazine), a Novel and Potent Nonpeptide Antagonist of the Melanocortin-4 Receptor; Shigeyuki Chaki et al, J. Pharm. Exp. Ther. (2003)304(2), 818-26).

Chronic diseases, such as malignant tumors or infections, are frequently associated with cachexia resulting from a combination of a decrease in appetite and a loss of lean body mass. Extensive loss of lean body mass is often triggered by an inflammatory process and is usually associated with increased plasma levels of cytokines (e.g. TNF- α), which increase the production of α -MSH in the brain. Activation of MC4 receptors in the hypothalamus by α -MSH reduces appetite and increases energy expenditure. Experimental evidence in tumor bearing mice suggests that cachexia can be prevented or reversed by genetic MC4 receptor knockout or MC4 receptor blockade. The increased body weight in the treated mice is attributable to a larger amount of lean body mass, which mainly consists of skeletal muscle (Marks D.L. et al. Role of the central melanocortin system in cachexia. Cancer Res. (2001) 61: 1432-1438).

In view of the unresolved deficiencies in treatment of various diseases and disorders as discussed above, it is an object of the present invention to provide novel substituted piperidine and piperazine derivatives with improved ability to cross the blood brain barrier, which are useful as melanocortin-4 receptor modulators to treat cancer cachexia, muscle wasting, anorexia, anxiety, depression, obesity, diabetes, sexual dysfunction and other diseases with MC-4R involvement.

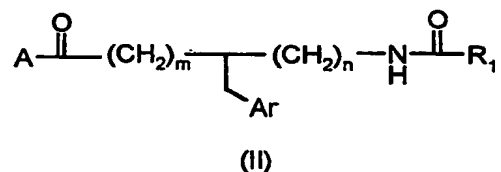
Summary of the Invention

The present invention relates to novel substituted piperidine and piperazine derivatives of structural formula (I),



wherein the variables A, R₁, Ar, m and n have the meaning as defined below.

The present invention also relates to novel substituted piperidine and piperazine derivatives of structural formula (II),



wherein the variables A, R₁, Ar, m and n have a different meaning than in structural formula (I) and are also defined below.

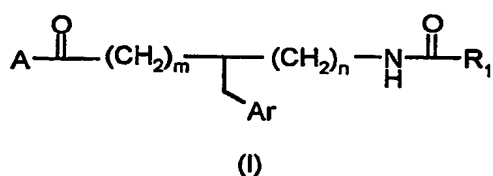
The piperidine and piperazine derivatives of structural formulas (I) and (II) are effective as melanocortin receptor modulators and are particularly effective as selective melanocortin-4 receptor (MC-4R) modulators. They are therefore useful for the treatment of disorders where the activation or inactivation of the MC-4R are involved. Agonists can be used for the treatment of disorders and diseases such as obesity, diabetes and sexual dysfunction, whereas the antagonists are useful for the treatment of disorders and diseases such as cancer cachexia, muscle wasting, anorexia, anxiety and depression.

The present invention also relates to pharmaceutical compositions comprising the compounds of the present invention and a pharmaceutically acceptable carrier.

Detailed Description of the Invention

The present invention relates to novel substituted piperidine and piperazine derivatives useful as melanocortin receptor modulators, in particular, selective MC-4R agonists and MC-4R antagonists.

The compounds of the present invention are represented by structural formula (I).

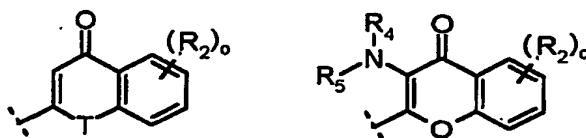


or a pharmaceutically acceptable salt or a solvate thereof, wherein

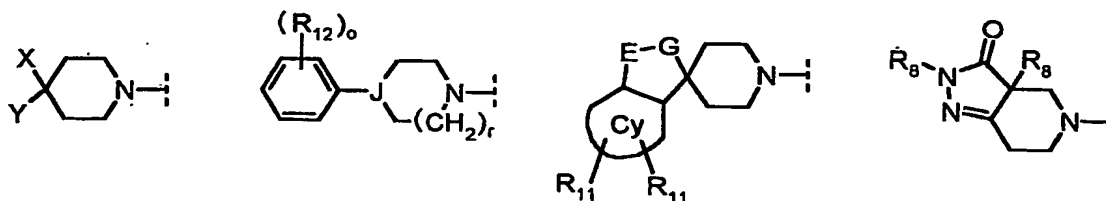
Ar is:

aryl or heteroaryl which may both be substituted;

R₁ is:



A is:



R₂ is independently:

hydrogen,

halo,

alkyl,

haloalkyl,

alkoxy,

(D)-cycloalkyl,

(D)-aryl,

(D)-heteroaryl,

(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and

wherein aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted or unsubstituted;

R₄ and R₅ are each independently:

hydrogen,

alkyl,

(D)-cycloalkyl or

R₄ and R₅ together with the nitrogen to which they are attached form a 5- to 8-membered ring,

wherein alkyl and cycloalkyl are unsubstituted or substituted;

R₈ is independently:

hydrogen,

alkyl,

(D)-aryl or

(D)-cycloalkyl;

R₉ is independently:

hydrogen,

alkyl,

(D)-aryl,

(D)-heteroaryl or
(D)-cycloalkyl;

R_{10} is independently:

R_9 ,
(D)-heterocyclyl,
(D)-N(Y)₂,
(D)-NH-heteroaryl or
(D)-NH-heterocyclyl,

wherein aryl and heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are substituted or unsubstituted, or

two R_{10} groups together with the atoms to which they are attached form a 5- to 8-membered mono- or bi-cyclic ring system;

R_{11} is:

hydrogen,
halo,
alkyl,
alkoxy,
C≡N,
CF₃ or
OCF₃;

R_{12} is independently:

hydrogen,
hydroxy,
cyano,
nitro,
halo,
alkyl,
alkoxy,
haloalkyl,
(D)-C(O)R₁₄,

(D)-C(O)OR₁₄,
 (D)-C(O)SR₁₄,
 (D)-C(O)-heteroaryl,
 (D)-C(O)-heterocyclyl,
 (D)-C(O)N(R₁₄)₂,
 (D)-N(R₁₄)₂,
 (D)-NR₁₄COR₁₄,
 (D)-NR₁₄CON(R₁₄)₂,
 (D)-NR₁₄C(O)OR₁₄,
 (D)-NR₁₄C(R₁₄)=N(R₁₄),
 (D)-NR₁₄C(=NR₁₄)N(R₁₄)₂,
 (D)-NR₁₄SO₂R₁₄,
 (D)-NR₁₄SO₂N(R₁₄)₂,
 (D)-NR₁₄(D)-heterocyclyl,
 (D)-NR₁₄(D)-heteroaryl,
 (D)-OR₁₄,
 OSO₂R₁₄,
 (D)[O]_q(cycloalkyl),
 (D)[O]_q(D)aryl,
 (D)[O]_q(D)-heteroaryl,
 (D)[O]_q(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen when q=1),
 (D)-SR₁₄,
 (D)-SOR₁₄,
 (D)-SO₂R₁₄ or
 (D)-SO₂N(R₁₄)₂,
 wherein alkyl, alkoxy, cycloalkyl, aryl, heterocyclyl and heteroaryl are substituted or unsubstituted;

R₁₄ is independently:

hydrogen,
 alkyl,
 haloalkyl,

(D)-cycloalkyl,
 (D)-phenyl,
 (D)-naphthyl,
 (D)-heteroaryl,
 (D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and
 wherein phenyl, naphthyl, heteroaryl, heterocyclyl, alkyl or cycloalkyl is substituted or unsubstituted;

X is:

alkyl,
 (D)-cycloalkyl,
 (D)-aryl,
 (D)-heteroaryl,
 (D)-heterocyclyl,
 (D)-C≡N,
 (D)-CON(R₉R₉),
 (D)-CO₂R₉,
 (D)-COR₉,
 (D)-NR₉C(O)R₉,
 (D)-NR₉CO₂R₉,
 (D)-NR₉C(O)N(R₉)₂,
 (D)-NR₉SO₂R₉,
 (D)-S(O)_pR₉,
 (D)-SO₂N(R₉)(R₉),
 (D)-OR₉,
 (D)-OC(O)R₉,
 (D)-OC(O)OR₉,
 (D)-OC(O)N(R₉)₂,
 (D)-N(R₉)(R₉) or
 (D)-NR₉SO₂N(R₉)(R₉),

wherein aryl, heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are unsubstituted or substituted;

Y is:

hydrogen,

alkyl,

(D)-cycloalkyl,

(D)-aryl,

(D)-heterocyclyl or

(D)-heteroaryl,

wherein aryl, heteroaryl, alkyl, D and cycloalkyl are unsubstituted or substituted;

Cy is benzene, pyridine or cyclohexane;

D is a bond or alkyl;

E is CHCO_2Y , $\text{CHC}(\text{O})\text{N}(\text{Y})_2$, $\text{NSO}_2\text{R}_{10}$, $\text{CHN}(\text{Y})\text{COR}_{10}$, $\text{CHN}(\text{Y})\text{SO}_2\text{R}_{10}$, CHCH_2OY or $\text{CHCH}_2\text{heteroaryl}$;

G is D, CH-alkyl, O, $\text{C}=\text{O}$ or SO_2 , with the proviso that when G is O, the ring atom E is carbon;

J is N or CH;

T is O or NR_4 ;

n is 0 - 2;

m is 0 - 2;

o is 0 - 3;

p is 0 - 2;

q is 0 or 1;

r is 1 - or 2.

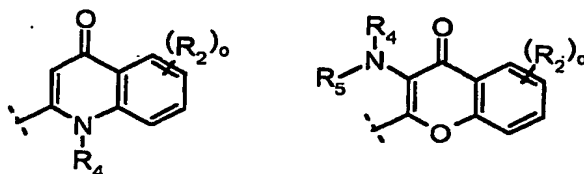
In preferred embodiments of formula I, the variants have the following meanings:

Ar is as defined above, and is preferably aryl, more preferably phenyl or naphthyl. If aryl or heteroaryl are substituted, it is preferably substituted with one to three, more preferably one

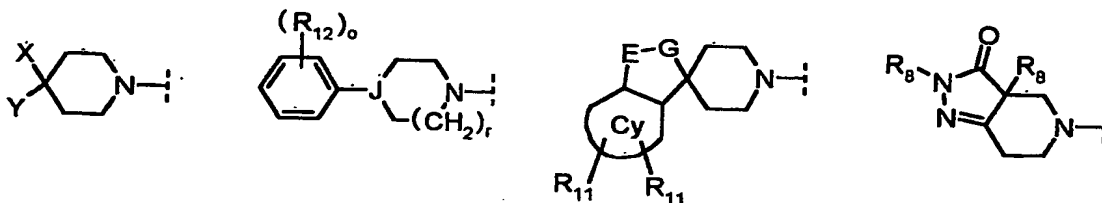
or two, most preferably one, substituents. The substituents are preferably independently selected from the group consisting of cyano, nitro, perfluoroalkoxy, halo, alkyl, (D)-cycloalkyl, alkoxy and haloalkyl, more preferably perfluoroalkoxy, halo, alkyl, alkoxy or haloalkyl, even more preferably halo, alkyl, alkoxy and/or haloalkyl, in particular halo.

Most preferably, Ar is phenyl or naphthyl which both, preferably phenyl, may be substituted with one to three, in particular one, halo, e.g. Cl. The substitution can be in any position, preferably in the 4-position.

R₁ is as defined above preferably:



A is:



R₂ is as defined above. If aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted, they are preferably independently substituted with one to three, more preferably one substituent selected from the group consisting of oxo, alkyl, N(R₆)₂, OR₆, SR₆ and/or CO₂R₆.

Preferably, R₂ is hydrogen, hydroxy, halo, alkyl, alkoxy, haloalkyl or (D)-cycloalkyl, more preferably hydrogen, alkoxy, halo or alkyl, e.g. methyl, ethyl, n-propyl, isopropyl.

R_4 and R_5 are each independently as defined above. When R_4 and R_5 form a ring, said ring may contain an additional heteroatom preferably selected from O, S and NR_6 in the ring. Moreover, if alkyl and cycloalkyl are substituted, they are preferably substituted with one to three, more preferably one or two groups independently selected from R_7 and oxo.

R_4 and R_5 are each independently preferably selected from the group consisting of hydrogen, alkyl or cycloalkyl; or R_4 and R_5 together with the nitrogen to which they are attached form a 5- to 7-membered ring. More preferably R_4 and R_5 are each independently selected from the group consisting of hydrogen or alkyl, or R_4 and R_5 together with the nitrogen to which they are attached form a 5- to 6-membered ring optionally containing an additional oxygen atom.

R_6 is independently hydrogen, alkyl, $C(O)$ alkyl, (D)-aryl or (D)-cycloalkyl, preferably hydrogen, alkyl, $C(O)$ alkyl, (D)-aryl or (D)-cycloalkyl, most preferably hydrogen.

R_7 is alkyl, (D)-aryl, (D)-cycloalkyl, (D)-heteroaryl, halo, OR_8 , $NHSO_2R_8$, $N(R_8)_2$, $C\equiv N$, CO_2R_8 , $C(R_8)(R_8)N(R_8)_2$, nitro, $SO_2N(R_8)_2$, $S(O)_pR_8$, CF_3 or OCF_3 , preferably hydrogen, alkyl, (D)-aryl or (D)-cycloalkyl, more preferably hydrogen.

R_8 is as defined above, preferably hydrogen, alkyl or (D)-aryl, more preferably alkyl or (D)-aryl.

R_9 is as defined above, preferably hydrogen, alkyl and (D)-cycloalkyl, more preferably alkyl, most preferably methyl, ethyl or tert-butyl.

R_{10} is as defined above. If aryl and heteroaryl are substituted, they are preferably independently substituted with one to three groups selected from R_7 . Moreover, if alkyl, D, cycloalkyl and heterocyclyl are substituted, they are preferably substituted with one to four groups independently selected from R_7 and oxo. If two R_{10} groups together with the atoms to which they are attached form a 5- to 8-membered mono- or bi-cyclic ring system, said ring may contain an additional heteroatom preferably selected from O, S, NR_8 , NBoc and NZ.

Preferably, R_{10} is R_9 .

R_{11} is defined as above, preferably hydrogen, halo, alkyl, alkoxy or $C\equiv N$, more preferably hydrogen, halo or $C_1 - C_4$ -alkyl, most preferably hydrogen.

R_{12} is as defined above. In particular, heterocyclyl includes azetidin-2-one-1-yl, pyrrolidin-2-one-1-yl, piperid-2-one-1-yl and azepan-2-one-1-yl. Moreover, if alkyl, alkoxy, cycloalkyl, aryl, heterocyclyl and heteroaryl are substituted, they are preferably substituted with 1 to 5, more preferably 1 to 3, most preferably 1 or 2 substituents independently selected from R_{13} .

Preferably, R_{12} is hydrogen, hydroxy, cyano, nitro, halo, alkyl, alkoxy, haloalkyl, $(D)-N(R_{14})_2$, $(D)-NR_{14}COR_{14}$, $(D)-NR_{14}CON(R_{14})_2$, $(D)-NR_{14}C(O)OR_{14}$, $(D)-NR_{14}C(R_{14})=N(R_{14})$, $(D)-NR_{14}C(=NR_{14})N(R_{14})_2$, $(D)-NR_{14}SO_2R_{14}$ or $(D)-NR_{14}SO_2N(R_{14})_2$, wherein alkyl or alkoxy are substituted or unsubstituted with one to five, preferably one to three, substituents selected from R_{13} . More preferably, R_{12} is cyano, nitro, halo, alkyl, $(D)-N(R_{14})_2$, $(D)-NR_{14}COR_{14}$, $(D)-NR_{14}CON(R_{14})_2$, $(D)-NR_{14}C(O)OR_{14}$ or $(D)-NR_{14}SO_2R_{14}$. Most preferably, R_{12} is cyano, nitro, halo or $NR_{14}COR_{14}$. Halo is preferably F, Cl or Br. R_{12} can be on any position of the ring, preferably in the 1-position.

R_{13} is independently hydrogen, halo, oxo, $N(R_{15})_2$, alkyl, (D) -cycloalkyl, haloalkyl, alkoxy, heteroaryl, hydroxy or heterocyclyl, wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen, phenyl, $(D)-COR_{14}$, $(D)-C(O)OR_{14}$, $(D)-OR_{14}$, $(D)-OCOR_{14}$, $(D)-OCO_2R_{14}$, $(D)-SR_{14}$, $(D)-SOR_{14}$ or $(D)-SO_2R_{14}$, wherein aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl is substituted or unsubstituted. If aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted, they are preferably substituted with one to three, preferably one or two, substituents selected from the group consisting of oxo, alkyl, $N(R_{15})_2$, OR_{15} , SR_{15} and/or CO_2R_{15} .

Preferably, R_{13} is hydrogen, halo, alkyl, (D) -cycloalkyl, alkoxy or phenyl, more preferably R_{13} is hydrogen, halo, alkyl, alkoxy or phenyl.

R_{14} is as defined above. If aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted, they are preferably substituted with one to three, more preferably one or two, substituents selected from the group consisting of oxo, alkyl, $N(R_{15})_2$, OR_{15} , SR_{15} and/or CO_2R_{15} .

Preferably, R_{14} is hydrogen, halo, alkyl, (D)cycloalkyl, alkoxy or phenyl, more preferably R_{14} is hydrogen, halo, alkyl, alkoxy or phenyl.

R_{15} is independently hydrogen, alkyl, C(O)alkyl, aryl or cycloalkyl, preferably hydrogen, alkyl or cycloalkyl, in particular, hydrogen.

X is as defined above. If aryl and heteroaryl are substituted, they are preferably substituted with one to three, more preferably one or two, groups selected from R_7 . Moreover, if alkyl, D, cycloalkyl and heterocyclyl are substituted, they are preferably substituted with one to four groups independently selected from R_7 and oxo.

Preferably, X is alkyl, (D)-cycloalkyl, (D)-aryl, (D)-heteroaryl, (D)-heterocyclyl, (D)-NHC(O) R_9 , (D)-CO₂ R_9 or (D)-CON(R_9R_9), more preferably from alkyl, (D)-cycloalkyl, (D)-heterocyclyl, (D)-NHC(O) R_9 or (D)-CON(R_9R_9), most preferably from C₁ - C₄-alkyl, C₅ - C₇-cycloalkyl, (D)-CON(R_9R_9) and N-containing heterocyclyl, in particular triazolyl and tetrazolyl.

Y is as defined above. If aryl and heteroaryl are substituted, they are preferably substituted with one to three, more preferably one or two, groups selected from R_7 . Moreover if alkyl, D and cycloalkyl are substituted, they are preferably substituted with one to three groups selected from R_7 and oxo.

Preferably, Y is hydrogen, alkyl, (D)-cycloalkyl, (D)-aryl, (D)-heteroaryl or (D)-heterocyclyl, more preferably hydrogen, alkyl, (D)-cycloalkyl or (D)-heterocyclyl, most preferably hydrogen, C₁ - C₄-alkyl or C₅ - C₇-cycloalkyl, in particular cyclohexyl.

Cy is as defined above, preferably benzene or pyridine, more preferably benzene.

D is as defined above, preferably a bond or C₁ - C₄-alkylene, more preferably a bond or CH₂.

E is as defined above, preferably NSO₂ R_{10} , CHN(Y)COR₁₀ or CHN(Y)SO₂ R_{10} , more preferably NSO₂ R_{10} .

G is as defined above, preferably D or CH-alkyl, more preferably D, in particular CH₂.

J is N or CH;

T is O or NR₄, preferably NR₄;

n is 0, 1 or 2, preferably 0 or 1;

m is 0, 1 or 2, preferably 0 or 1;

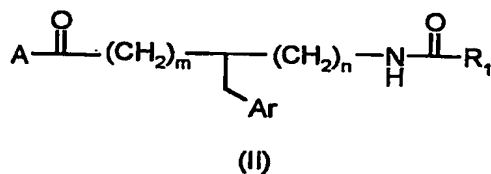
o is 0, 1, 2 or 3, preferably 0, 1 or 2, more preferably 0 or 1;

p is 0, 1 or 2;

q is 0 or 1;

r is 1 or 2, preferably 1.

Compounds of the present invention are also represented by structural formula (II),

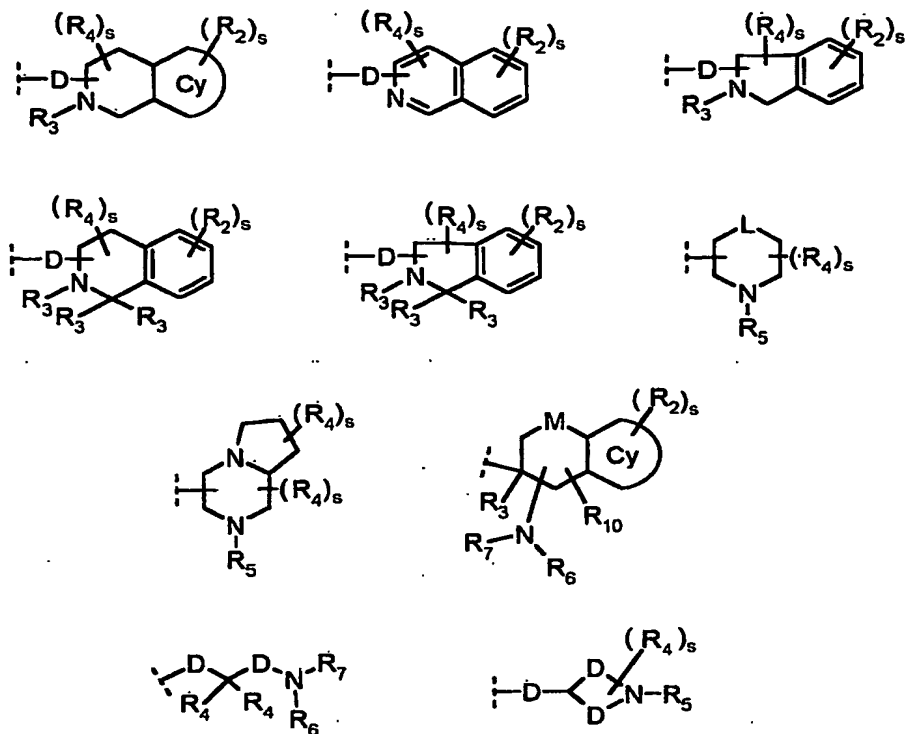


or a pharmaceutically acceptable salt or a solvate thereof, wherein

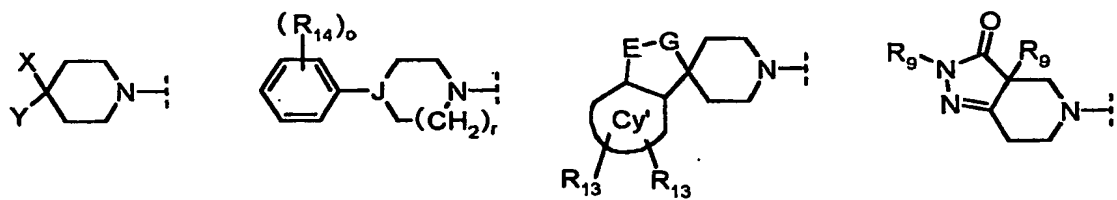
Ar is:

aryl or heteroaryl, which may both be substituted;

R_1 is:



A is:



R_2 is independently:

hydrogen,
halo,
alkyl,
haloalkyl,
alkoxy,
(D)-cycloalkyl,
(D)-aryl,

(D)-heteroaryl,
 (D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and
 wherein aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted or unsubstituted.

R₃ is independently:

hydrogen,
 alkyl,
 SO₂alkyl,
 SO₂aryl,
 C(O)alkyl,
 (D)-aryl or
 cycloalkyl;

R₄ is independently:

hydrogen,
 alkyl,
 (D)-aryl,
 (D)-heteroaryl,
 (D)-N(R₆)₂,
 (D)-NR₆C(O)alkyl,
 (D)-NR₆SO₂alkyl,
 (D)-SO₂N(R₆)₂,
 (D)-(O)_valkyl,
 (D)-(O)_v(D)NR₆COR₆,
 (D)-(O)_v(D)NR₇SO₂R₇,
 (D)-(O)_v-heterocyclyl or
 (D)-(O)_v(alkyl)-heterocyclyl;

R₅ is independently:

hydrogen,
 alkyl,

(D)-phenyl,
 C(O)alkyl,
 C(O)phenyl,
 SO₂-alkyl or
 SO₂-phenyl;

R₆ and R₇ are each independently:

hydrogen,
 alkyl,
 cycloalkyl, or

R₆ and R₇ together with the nitrogen to which they are attached form a 5- to 8-membered ring,

wherein alkyl and cycloalkyl are unsubstituted or substituted;

R₉ is independently:

hydrogen,
 alkyl,
 (D)-aryl or
 cycloalkyl;

R₁₀ is hydrogen or alkyl;

R₁₁ is independently:

hydrogen,
 alkyl,
 (D)-aryl,
 (D)-heteroaryl or
 (D)-cycloalkyl;

R₁₂ is independently:

R₁₁,
 (D)-heterocyclyl,
 (D)-N(Y)₂,

(D)-NH-heteroaryl or

(D)-NH-heterocyclyl,

wherein aryl, heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are unsubstituted or substituted, or

two R_{12} groups together with the atoms to which they are attached form a 5- to 8-membered mono- or bicyclic ring system;

R_{13} is:

hydrogen,

halo,

alkyl,

alkoxy,

$C\equiv N$,

CF_3 or

OCF_3 ;

R_{14} is independently:

hydrogen,

hydroxy,

cyano,

nitro,

halo,

alkyl,

alkoxy,

haloalkyl,

(D)- $C(O)R_{16}$,

(D)- $C(O)OR_{16}$,

(D)- $C(O)SR_{16}$,

(D)- $C(O)$ -heteroaryl,

(D)- $C(O)$ -heterocyclyl,

(D)- $C(O)N(R_{16})_2$,

(D)- $N(R_{16})_2$,

(D)- $NR_{16}COR_{16}$,

(D)-NR₁₆CON(R₁₆)₂,

(D)-NR₁₆C(O)OR₁₆,

(D)-NR₁₆C(R₁₆)=N(R₁₆),

(D)-NR₁₆C(=NR₁₆)N(R₁₆)₂,

(D)-NR₁₆SO₂R₁₆,

(D)-NR₁₆SO₂N(R₁₆)₂,

(D)-NR₁₆(D)-heterocyclyl,

(D)-NR₁₆(D)-heteroaryl,

(D)-OR₁₆,

OSO₂R₁₆,

(D)-[O]_q(cycloalkyl),

(D)-[O]_q(D)aryl,

(D)-[O]_q(D)-heteroaryl,

(D)-[O]_q(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen when q=1),

(D)-SR₁₆,

(D)-SOR₁₆,

(D)-SO₂R₁₆ or

(D)-SO₂N(R₁₆)₂,

wherein alkyl, alkoxy, cycloalkyl, aryl, heterocyclyl and heteroaryl are substituted or unsubstituted;

R₁₆ is independently:

hydrogen,

alkyl,

haloalkyl,

(D)-cycloalkyl,

(D)-aryl,

(D)-heteroaryl,

(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and

wherein aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl is substituted or unsubstituted;

Cy is:

aryl,
heteroaryl,
heterocyclyl or
carbocyclyl;

X is :

alkyl,
(D)-cycloalkyl,
(D)-aryl,
(D)-heteroaryl,
(D)-heterocyclyl,
(D)-C≡N,
(D)-CON(R₁₁R₁₁),
(D)-CO₂R₁₁,
(D)-COR₁₁,
(D)-NR₁₁C(O)R₁₁,
(D)-NR₁₁CO₂R₁₁,
(D)-NR₁₁C(O)N(R₁₁)₂,
(D)-NR₁₁SO₂R₁₁,
(D)-S(O)_pR₁₁,
(D)-SO₂N(R₁₁)(R₁₁),
(D)-OR₁₁,
(D)-OC(O)R₁₁,
(D)-OC(O)OR₁₁,
(D)-OC(O)N(R₁₁)₂,
(D)-N(R₁₁)(R₁₁) or
(D)-NR₁₁SO₂N(R₁₁)(R₁₁),

wherein aryl, heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are unsubstituted or substituted;

Y is:

hydrogen,

alkyl,

(D)-cycloalkyl,

(D)-aryl,

(D)-heterocyclyl or

(D)-heteroaryl,

wherein aryl, heteroaryl, alkyl, D and cycloalkyl are unsubstituted or substituted;

Cy' is benzene, pyridine or cyclohexane;

D is a bond or alkylene;

E is CHCO_2Y , $\text{CHC}(\text{O})\text{N}(\text{Y})_2$, $\text{NSO}_2\text{R}_{10}$, $\text{CHN}(\text{Y})\text{COR}_{12}$, $\text{CHN}(\text{Y})\text{SO}_2\text{R}_{12}$, CHCH_2OY or $\text{CHCH}_2\text{heteroaryl}$;

G is D, CH-alkyl, O, C=O or SO_2 , with the proviso that when G is O, the ring atom E is carbon;

J is N or CH;

L is O, S or NR_5 ;

M is bond, O, $\text{S}(\text{O})_u$, NR_5 or CH_2 ;

n is 0 - 2, unless m is 0, then n is 1 or 2;

m is 0 - 2, unless n is 0, then m is 1 or 2;

o is 0 - 3;

p is 0 - 2;

q is 0 or 1;

r is 1 or 2;

s is 0 - 5;

u is 0 - 2;

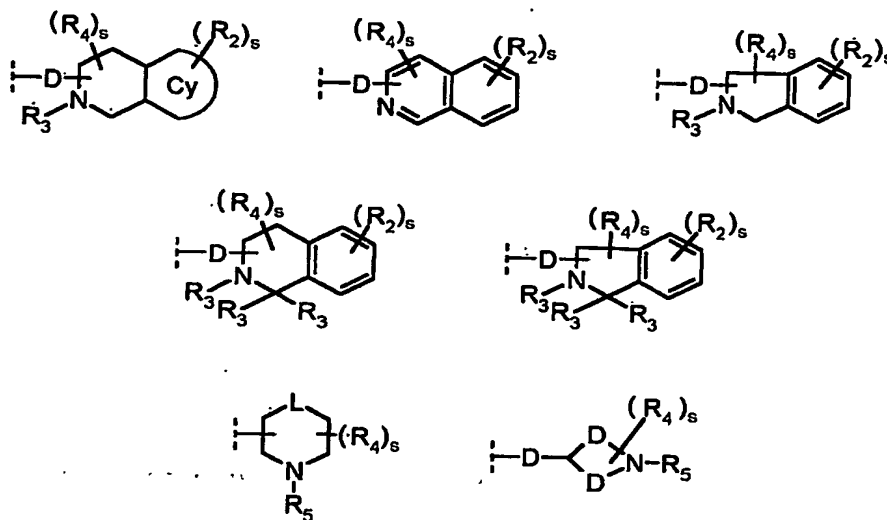
v is 0 or 1.

In preferred embodiments of formula II, the variants have the following meanings:

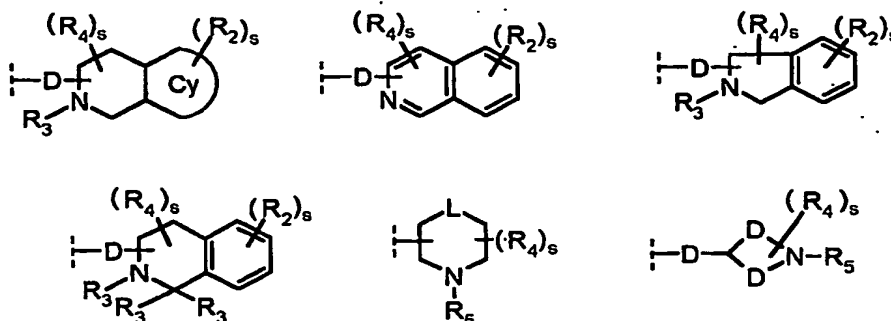
Ar is as defined above, and is preferably aryl, more preferably phenyl or naphthyl. If aryl or heteroaryl are substituted, it is preferably substituted with one to three, more preferably one or two, most preferably one, substituents. The substituents are preferably independently selected from the group consisting of: cyano, nitro, perfluoroalkoxy, halo, alkyl, (D)-cycloalkyl, alkoxy and haloalkyl, more preferably cyano, perfluoroalkoxy, halo, alkyl, (D)-cycloalkyl, alkoxy or haloalkyl, even more preferably halo, alkyl, alkoxy and/or haloalkyl, in particular halo.

Most preferably, Ar is phenyl or naphthyl which both, preferably phenyl, may be substituted with one to three, in particular one, halo, e.g. Cl. The substitution can be in any position, preferably in the 4-position.

R₁ is as defined above, preferably:



More preferably, R_1 is:



A is as defined above.

R_2 is as defined above. If aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted, they are preferably substituted with one to three substituents, more preferably one, selected from the group consisting of oxo, alkyl, $N(R_3)_2$, OR_3 , SR_3 and/or CO_2R_3 .

Preferably, R_2 is hydrogen, halo, alkyl, haloalkyl, alkoxy or (D)-cycloalkyl, more preferably hydrogen, halo or alkyl, e.g. methyl, ethyl, n-propyl, iso-propyl, most preferably hydrogen.

R_3 is as defined above, preferably hydrogen or alkyl, e.g. methyl, ethyl, n-propyl, iso-propyl, more preferably hydrogen.

R_4 is as defined above, preferably hydrogen, (D)-aryl, (D)-heteroaryl, (D)- $N(R_7)_2$, (D)- $NR_7C(O)alkyl$, (D)- NR_7SO_2alkyl or alkyl, e.g. methyl, ethyl, n-propyl, iso-propyl, more preferably hydrogen.

R_5 is as defined above, preferably hydrogen or alkyl, e.g. methyl, ethyl, n-propyl, iso-propyl, more preferably hydrogen.

R_6 and R_7 are each independently as defined above. When R_6 and R_7 form a ring, said ring may contain an additional heteroatom preferably selected from O, S and NR_3 in the ring. Moreover, if alkyl and cycloalkyl are substituted, they are preferably substituted with one to three, more preferably one or two, groups independently selected from R_8 and/or oxo.

R_6 and R_7 are each independently preferably selected from the group consisting of hydrogen, alkyl or cycloalkyl, or R_6 and R_7 together with the nitrogen to which they are attached form a 5- to 7-membered ring. More preferably R_6 and R_7 are each independently selected from the group consisting of hydrogen or alkyl, or R_6 and R_7 together with the nitrogen to which they are attached form a 5- to 6-membered ring optionally containing an additional oxygen atom.

R_8 is alkyl, (D)-aryl, (D)-cycloalkyl, (D)-heteroaryl, halo, OR_9 , $NHSO_2R_9$, $N(R_9)_2$, $C\equiv N$, CO_2R_9 , $C(R_9)(R_9)N(R_9)_2$, nitro, $SO_2N(R_9)_2$, $S(O)_nR_9$, CF_3 or OCF_3 . Preferably R_8 is alkyl, OR_9 , (D)-aryl, (D)-cycloalkyl, (D)-heteroaryl or halo.

R_9 is as defined above, preferably hydrogen, (D)-aryl or alkyl, e.g. methyl, ethyl, n-propyl, iso-propyl, more preferably hydrogen or (D)-aryl.

R_{10} is as defined above, preferably hydrogen or $C_1 - C_4$ alkyl as defined below, more preferably hydrogen, methyl or ethyl, most preferably hydrogen or methyl.

R_{11} is as defined above, preferably hydrogen or alkyl, more preferably hydrogen or $C_1 - C_6$ alkyl as defined below, in particular $C_1 - C_5$ alkyl, e.g. methyl, ethyl, n-propyl, iso-propyl, n-butyl, iso-butyl, tert-butyl and n-pentyl, most preferably hydrogen or tert-butyl.

R_{12} is as defined above. If aryl and heteroaryl are substituted, they are preferably substituted with one to three, more preferably one or two, groups selected from R_7 . Moreover, if alkyl, D, cycloalkyl and heterocyclyl are substituted, they are preferably substituted with one to four, more preferably one or two, groups independently selected from R_8 and/or oxo. Furthermore, if two R_{12} groups together with the atoms to which they are attached form a 5- to 8-membered mono- or bi-cyclic ring system, said ring may contain an additional heteroatom preferably selected from O, S, NR_9 , NBoc and NZ.

Preferably, R_{12} is R_{11} .

R_{13} is as defined above, preferably hydrogen, halo, alkyl, alkoxy and $C\equiv N$, more preferably hydrogen, methyl or ethyl, most preferably hydrogen or methyl.

R_{14} is as defined above. In particular, heterocyclyl includes azetidin-2-one-1-yl, pyrrolidin-2-one-1-yl, piperid-2-one-1-yl and azepan-2-one-1-yl. Moreover, if alkyl, alkoxy, cycloalkyl, aryl, heterocyclyl and heteroaryl are substituted, they are preferably substituted with 1 to 5, more preferably 1 to 3, most preferably 1 or 2, substituents independently selected from R_{15} .

Preferably, R_{14} is hydrogen, hydroxy, cyano, nitro, halo, alkyl, alkoxy, haloalkyl, $(D)-N(R_{16})_2$, $(D)-NR_{16}COR_{14}$, $(D)-NR_{14}CON(R_{14})_2$, $(D)-NR_{14}C(O)OR_{16}$, $(D)-NR_{16}C(R_{16})=N(R_{16})$, $(D)-NR_{16}C(=NR_{16})N(R_{16})_2$, $(D)-NR_{16}SO_2R_{16}$ or $(D)-NR_{16}SO_2N(R_{16})_2$, wherein alkyl or alkoxy are substituted or unsubstituted with one to five, preferably one to three, substituents selected from R_{15} . More preferably, R_{14} is cyano, nitro, halo, alkyl, $(D)-N(R_{16})_2$, $(D)-NR_{16}COR_{16}$, $(D)-NR_{16}CON(R_{16})_2$, $(D)-NR_{16}C(O)OR_{16}$ or $(D)-NR_{16}SO_2R_{16}$. Most preferably, R_{16} is cyano, nitro, halo or $NR_{16}COR_{16}$. Halo is preferably F, Cl or Br. R_{14} can be on any position of the ring, preferably in the 1-position.

R_{15} is independently hydrogen, halo, oxo, $N(R_3)_2$, alkyl, (D) -cycloalkyl, alkoxy, haloalkyl, heteroaryl, hydroxy, heterocyclyl, wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen, phenyl, $(D)-COR_{16}$, $(D)-C(O)OR_{16}$, $(D)-OR_{16}$, $(D)-OCOR_{16}$, $(D)-OCO_2R_{16}$, $(D)-SR_{16}$, $(D)-SOR_{16}$ or $(D)-SO_2R_{16}$, wherein aryl, heteroaryl, heterocyclyl, alkyl and cycloalkyl are substituted or unsubstituted. If aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted, they are preferably substituted with one to three, more preferably one or two, substituents selected from the group consisting of oxo, alkyl, $N(R_{16})_2$, OR_{16} , SR_{16} and/or CO_2R_{16} .

Preferably, R_{15} is hydrogen, halo, alkyl, (D) -cycloalkyl, alkoxy or phenyl, more preferably R_{15} is hydrogen, halo, alkyl, alkoxy or phenyl.

R_{16} is as defined above. If aryl, heteroaryl, heterocyclyl, alkyl or cycloalkyl are substituted, they are preferably substituted with one to three, more preferably one or two, substituents selected from the group consisting of oxo, alkyl, $N(R_3)_2$, OR_3 , SR_3 and/or CO_2R_3 .

Preferably, R_{16} is hydrogen, halo, alkyl, (D) -cycloalkyl, alkoxy or phenyl, more preferably R_{16} is hydrogen, halo, alkyl, alkoxy or phenyl.

Cy is as defined above wherein heteroaryl and heterocyclyl are preferably 5- or 6-membered and carbocyclyl is preferably 5- or 7-membered. Preferably Cy is aryl, more preferably benzene.

X is as defined above. If aryl and heteroaryl are substituted, they are preferably substituted with one to three, more preferably one or two, groups selected from R_8 . Moreover, if alkyl, D, cycloalkyl and heterocyclyl are substituted, they are preferably substituted with one to four groups independently selected from R_8 and/or oxo.

Preferably, X is alkyl, (D)-cycloalkyl, (D)-aryl, (D)-heteroaryl, (D)-heterocyclyl, (D)-NHC(O) R_{11} , (D)-CO₂ R_{11} or (D)-CON(R_{11} R_{11}), more preferably alkyl, (D)-cycloalkyl, (D)-heterocyclyl, (D)-NHC(O) R_{11} or (D)-CON(R_{11} R_{11}), most preferably C₁ - C₄-alkyl, C₅ - C₇-cycloalkyl, (D)-CON(R_{11} R_{11}) and N-containing heterocyclyl, in particular triazolyl and tetrazolyl.

Y is as defined above. If aryl and heteroaryl are substituted, they are preferably substituted with one to three, more preferably one or two, groups selected from R_8 . Moreover, if alkyl, D and cycloalkyl are substituted, they are preferably substituted with one to three groups selected from R_8 and/or oxo.

Preferably, Y is hydrogen, alkyl, (D)-cycloalkyl, (D)-aryl, (D)-heteroaryl or (D)-heterocyclyl, more preferably alkyl, (D)-cycloalkyl or (D)-heterocyclyl, most preferably hydrogen, C₁ - C₄-alkyl and C₅ - C₇-cycloalkyl, in particular cyclohexyl.

Cy' is as defined above, preferably benzene or pyridine, more preferably benzene.

D is as defined above, preferably a bond or C₁ - C₄ alkylene, more preferably a bond or CH₂.

E is as defined above, preferably NSO₂ R_{10} , CHN(Y)COR₁₂ or CHN(Y)SO₂ R_{12} , more preferably NSO₂ R_{10} .

G is as defined above, preferably D or CH alkyl, more preferably D, in particular CH₂.

J is as defined above;

L is as defined above, preferably NR_5 ;

M is as defined above, preferably bond or CH_2 ;

n is 0, 1 or 2, preferably 0 or 1, unless m is 0, then n is 1;

m is 0, 1 or 2, preferably 0 or 1, unless n is 0, then m is 1, more preferably $n+m=1$;

o is 0, 1, 2 or 3, preferably 0, 1 or 2, more preferably 1;

p is 0 or 1, preferably 0;

q is 0 or 1, preferably 0;

r is 1 or 2, preferably 1;

s is 0, 1, 2, 3, 4 or 5, preferably 0, 1, 2 or 3, more preferably 0 or 1, most preferably 0;

u is 0, 1 or 2;

v is 0 or 1.

In the above and the following, the employed terms have the meaning as described below:

Aryl is an aromatic mono- or polycyclic moiety with 6 to 20 carbon atoms which is preferably selected from phenyl, biphenyl, naphthyl, tetrahydronaphthyl, fluorenyl, indenyl or phenanthrenyl, more preferably from phenyl or naphthyl.

Heteroaryl is an aromatic moiety having 6 to 20 carbon atoms with at least one heterocycle and is preferably selected from thienyl, benzothienyl, naphthothienyl, furanyl, benzofuranyl, chromenyl, indolyl, isoindolyl, indazolyl, quinolyl, isoquinolyl, phthalazinyl, quinoxaliny, cinnoliny or quinazolinyl, more preferably from thienyl, furanyl, benzothienyl, benzofuranyl or indolyl.

Heterocyclyl is a saturated, unsaturated or aromatic ring containing at least one heteroatom selected from O, N and/or S and 1 to 6 carbon atoms and is preferably selected from azetidin-2-one-1-yl, pyrrolidin-2-one-1-yl, piperid-2-one-1-yl and azepan-2-one-1-yl, thienyl, furyl, piperidinyl, pyranyl, pyrrolyl, imidazolyl, pyrazolyl, pyridyl, pyrazinyl, pyrimidinyl, pyridazinyl, isothiazolyl or isoxazyl, more preferably from pyridyl, piperidinyl, imidazolyl or pyrazinyl.

Carbocyclyl is a monocyclic or polycyclic ring system of 3 to 20 carbon atoms which may be saturated, unsaturated or aromatic.

Alkyl is straight chain or branched alkyl having preferably 1 to 8 carbon atoms, such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, hexyl or heptyl, more preferably 1 to 4 carbon atoms.

Cycloalkyl is an alkyl ring having preferably 3 to 8 carbon atoms, such as cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl or cyclooctyl, more preferably 3 to 6 carbon atoms.

Alkoxy is O-alkyl wherein alkyl is as defined above and has preferably 1 to 4 carbon atoms, preferably 1 or 2 carbon atoms.

Halo or halogen is a halogen atom preferably selected from F, Cl, Br and I, preferably F, Cl and Br.

Haloalkyl is an alkyl moiety as defined above having preferably 1 to 4 carbon atoms, more preferably 1 or 2 carbon atoms, wherein at least one, preferably 1 to 3 hydrogen atoms, have been replaced by a halogen atom. Preferred examples are $-\text{CF}_3$, $-\text{CH}_2\text{CF}_3$ and $-\text{CF}_2\text{CF}_3$.

Therein, the alkylene moiety may be a straight chain or branched chain group. Said alkylene moiety preferably has 1 to 6 carbon atoms. Examples thereof include methylene, ethylene, n-propylene, n-butylene, n-pentylene, n-hexylene, iso-propylene, sec.-butylene, tert.-butylene, 1,1-dimethyl propylene, 1,2-dimethyl propylene, 2,2-dimethyl propylene, 1,1-dimethyl butylene, 1,2-dimethyl butylene, 1,3-dimethyl butylene, 2,2-dimethyl butylene, 2,3-dimethyl butylene, 3,3-dimethyl butylene, 1-ethyl butylene, 2-ethyl butylene, 3-ethyl butylene, 1-n-propyl propylene, 2-n-propyl propylene, 1-iso-propyl propylene, 2-iso-propyl propylene, 1-methyl pentylene, 2-methyl pentylene, 3-methyl pentylene and 4-methyl pentylene. More preferably, said alkylene moiety has 1 to 3 carbon atoms, such as methylene, ethylene, n-propylene and iso-propylene. Most preferred is methylene.

The compounds of structural formulas (I) and (II) are effective as melanocortin receptor modulators and are particularly effective as selective modulators of MC-4R. They are therefore useful for the treatment and/or prevention of disorders responsive to the activation and inactivation of MC-4R, such as cancer cachexia, muscle wasting, anorexia, anxiety, depression, obesity, diabetes, sexual dysfunction and other diseases with MC-4R involvement.

Optical Isomers - Diastereomers - Geometric Isomers - Tautomers

Compounds of structural formulas (I) and (II) contain one or more asymmetric centers and can occur as racemates and racemic mixtures, single enantiomers, diastereomeric mixtures and individual diastereomers. The present invention is meant to comprehend all such isomeric forms of the compounds of structural formulas (I) and (II).

Some of the compounds described herein may exist as tautomers, such as keto-enol tautomers. The individual tautomers, as well as mixtures thereof, are encompassed within the compounds of structural formulas (I) and (II).

Compounds of structural formulas (I) and (II) may be separated into their individual diastereoisomers by, for example, fractional crystallization from a suitable solvent, for example methanol or ethyl acetate or a mixture thereof, or via chiral chromatography using an optically active stationary phase. Absolute stereochemistry may be determined by X-ray crystallography of crystalline products or crystalline intermediates which are derivatized, if necessary, with a reagent containing an asymmetric center of known absolute configuration.

Alternatively, any stereoisomer of a compound of the general formulas (I) and (II) may be obtained by stereospecific synthesis using optically pure starting materials or reagents of known absolute configuration.

Salts

The term "pharmaceutically acceptable salts" refers to salts prepared from pharmaceutically acceptable non-toxic bases or acids including inorganic or organic bases and inorganic or organic acids. Salts derived from inorganic bases include aluminum, ammonium, calcium, copper, ferric, ferrous, lithium, magnesium, manganic salts, manganous, potassium, sodium, zinc and the like. Particularly preferred are the ammonium, calcium, lithium, magnesium, potassium and sodium salts. Salts derived from pharmaceutically acceptable organic non-toxic bases include salts of primary, secondary and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion-exchange resins, such as arginine, betaine, caffeine, choline, N,N'-dibenzylethylenediamine, diethylamine, 2-diethylaminoethanol, 2-dimethylaminoethanol, ethanolamine, ethylenediamine, N-ethylmorpholine, N-ethylpiperidine, glucamine, glucosamine, histidine, hydrabamine, isopropylamine, lysine, methylglucamine, morpholine, piperazine, piperidine, polyamine resins, procaine, purines, theobromine, triethylamine, trimethylamine, tripropylamine, tromethamine and the like.

When the compound of the present invention is basic, salts may be prepared from pharmaceutically acceptable non-toxic acids, including inorganic and organic acids. Such acids include acetic, benzenesulfonic, benzoic, camphorsulfonic, citric, ethanesulfonic, formic, fumaric, gluconic, glutamic, hydrobromic, hydrochloric, isethionic, lactic, maleic, malic, mandelic, methanesulfonic, malonic, mucic, nitric, pantoic, pantothenic, phosphoric, propionic, succinic, sulfuric, tartaric, p-toluenesulfonic, trifluoroacetic acid and the like. Particularly preferred are citric, fumaric, hydrobromic, hydrochloric, maleic, phosphoric, sulfuric and tartaric acids.

It will be understood that, as used herein, references to the compounds of formulas (I) and (II) are meant to also include the pharmaceutically acceptable salts.

Utility

Compounds of formulas (I) and (II) are melanocortin receptor modulators and as such are useful in the treatment, control or prevention of diseases, disorders or conditions responsive to the activation or inactivation of one or more of the melanocortin receptors including, but not limited to, MC-1R, MC-2R, MC-3R, MC-4R or MC-5R. Such diseases, disorders or conditions include, but are not limited to, cancer cachexia, muscle wasting, anorexia, anxiety, depression, obesity (by reducing appetite, increasing metabolic rate, reducing fat intake or reducing carbohydrate craving), diabetes mellitus (by enhancing glucose tolerance, decreasing insulin resistance), hypertension, hyperlipidemia, osteoarthritis, cancer, gall bladder disease, sleep apnea, depression, anxiety, compulsion, neuroses, insomnia/sleep disorder, substance abuse, pain, male and female sexual dysfunction (including impotence, loss of libido and erectile dysfunction), fever, inflammation, immune-modulation, rheumatoid arthritis, skin tanning, acne and other skin disorders, neuroprotective and cognitive and memory enhancement including the treatment of Alzheimer's disease.

Some compounds encompassed by formulas (I) and (II) show highly selective affinity for the melanocortin-4 receptor relative to MC-1R, MC-2R, MC-3R and MC-5R, which makes them especially useful in the prevention and treatment of cancer cachexia, muscle wasting, anorexia, anxiety, depression, obesity, as well as male and/or female sexual dysfunction, including erectile dysfunction. "Male sexual dysfunction" includes impotence, loss of libido and erectile dysfunction. "Female sexual dysfunction" can be seen as resulting from multiple components including dysfunction in desire, sexual arousal, sexual receptivity and orgasm.

Administration and Dose Ranges

Any suitable route of administration may be employed for providing a mammal, especially a human with an effective dosage of a compound of the present invention. For example, oral, rectal, topical, parenteral, ocular, pulmonary, nasal and the like may be employed. Dosage forms include tablets, troches, dispersions, suspensions, solutions, capsules, creams, ointments, aerosols and the like. Preferably compounds of formulas (I) and (II) are administered orally or topically.

The effective dosage of active ingredient employed may vary depending on the particular compound employed, the mode of administration, the condition being treated and the severity of the condition being treated. Such dosage may be ascertained readily by a person skilled in the art.

When treating cancer cachexia, muscle wasting or anorexia generally satisfactory results are obtained when the compounds of the present invention are administered at a daily dosage of from about 0.001 milligram to about 100 milligrams per kilogram of body weight, preferably given in a single dose or in divided doses two to six times a day, or in sustained release form. In the case of a 70 kg adult human, the total daily dose will generally be from about 0.07 milligrams to about 3500 milligrams. This dosage regimen may be adjusted to provide the optimal therapeutic response.

When treating obesity, in conjunction with diabetes and/or hyperglycemia, or alone, generally satisfactory results are obtained when the compounds of the present invention are administered at a daily dosage of from about 0.001 milligram to about 100 milligrams per kilogram of body weight, preferably given in a single dose or in divided doses two to six times a day, or in sustained release form. In the case of a 70 kg adult human, the total daily dose will generally be from about 0.07 milligrams to about 3500 milligrams. This dosage regimen may be adjusted to provide the optimal therapeutic response.

When treating diabetes mellitus and/or hyperglycemia, as well as other diseases or disorders for which compounds of formulas I and (II) are useful, generally satisfactory results are obtained when the compounds of the present invention are administered at a daily dosage of from about 0.001 milligram to about 100 milligram per kilogram of animal body weight, preferably given in a single dose or in divided doses two to six times a day, or in sustained release form. In the case of a 70 kg adult human, the total daily dose will generally be from about 0.07 milligrams to about 3500 milligrams. This dosage regimen may be adjusted to provide the optimal therapeutic response.

For the treatment of sexual dysfunction, compounds of the present invention are given in a dose range of 0.001 milligram to about 100 milligram per kilogram of body weight, preferably as a single dose orally or as a nasal spray.

Formulation

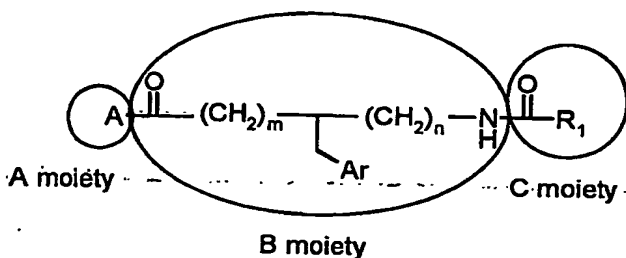
The compound of formulas (I) and (II) is preferably formulated into a dosage form prior to administration. Accordingly the present invention also includes a pharmaceutical composition comprising a compound of formulas (I) and (II) and a suitable pharmaceutical carrier.

The present pharmaceutical compositions are prepared by known procedures using well-known and readily available ingredients. In making the formulations of the present invention, the active ingredient (a compound of formulas (I) and (II)) is usually mixed with a carrier, or diluted by a carrier, or enclosed within a carrier, which may be in the form of a capsule, sachet, paper or other container. When the carrier serves as a diluent, it may be a solid, semisolid or liquid material which acts as a vehicle, excipient or medium for the active ingredient. Thus, the compositions can be in the form of tablets, pills, powders, lozenges, sachets, cachets, elixirs, suspensions, emulsions, solutions, syrups, aerosol (as a solid or in a liquid medium), soft and hard gelatin capsules, suppositories, sterile injectable solutions and sterile packaged powders.

Some examples of suitable carriers, excipients and diluents include lactose, dextrose, sucrose, sorbitol, mannitol, starches, gum acacia, calcium phosphate, alginates, tragacanth, gelatin, calcium silicate, microcrystalline cellulose, polyvinylpyrrolidone, cellulose, water syrup, methyl cellulose, methyl and propylhydroxybenzoates, talc, magnesium stearate and mineral oil. The formulations can additionally include lubricating agents, wetting agents, emulsifying and suspending agents, preserving agents, sweetening agents or flavoring agents. The compositions of the invention may be formulated so as to provide quick, sustained or delayed release of the active ingredient after administration to the patient.

Preparation of Compounds of the Invention

When describing the preparation of the present compounds of formulas (I) and (II), the terms "A moiety", "B moiety" and "C moiety" are used below. This moiety concept is illustrated below:



Preparation of the compounds of the present invention may be carried out via sequential or convergent synthetic routes. The skilled artisan will recognize that, in general, the three moieties of a compound of formulas (I) and (II) are connected via amide bonds. The skilled artist can, therefore, readily envision numerous routes and methods of connecting the three moieties via standard peptide coupling reaction conditions.

The phrase "standard peptide coupling reaction conditions" means coupling a carboxylic acid with an amine using an acid activating agent such as EDC, dicyclohexylcarbodiimide and benzotriazol-1-yloxytris(dimethylamino)-phosphonium hexafluorophosphate, in a inert solvent such as DCM, in the presence of a catalyst such as HOBt. The uses of protective groups for amine and carboxylic acids to facilitate the desired reaction and minimize undesired reactions are well documented. Conditions required to remove protecting groups which may be present can be found in Greene, et al., *Protective Groups in Organic Synthesis*, John Wiley & Sons, Inc., New York, NY 1991.

Protecting groups like Z, Boc and Fmoc are used extensively in the synthesis, and their removal conditions are well known to those skilled in the art. For example, removal of Z groups can be achieved by catalytic hydrogenation with hydrogen in the presence of a noble metal or its oxide, such as palladium on activated carbon in a protic solvent, such as ethanol. In cases where catalytic hydrogenation is contraindicated by the presence of other potentially reactive functionality, removal of Z can also be achieved by treatment with a

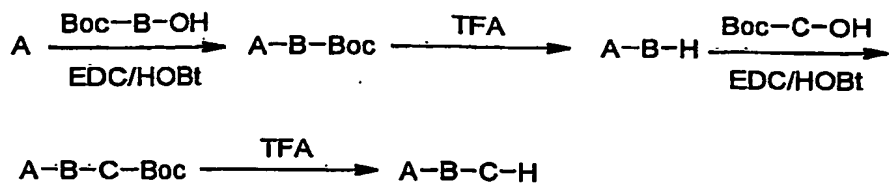
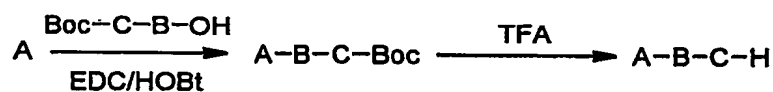
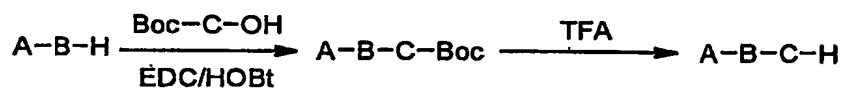
solution of hydrogen bromide in acetic acid, or by treatment with a mixture of TFA and dimethylsulfide. Removal of Boc protecting groups is carried out in a solvent such as methylene chloride, methanol or ethyl acetate with a strong acid, such as TFA or HCl or hydrogen chloride gas.

The compounds of formulas (I) and (II), when existing as a diastereomeric mixture, may be separated into diastereomeric pairs of enantiomers by fractional crystallization from a suitable solvent such as methanol, ethyl acetate or a mixture thereof. The pair of enantiomers 5 thus obtained may be separated into individual stereoisomers by conventional means by using an optically active acid as a resolving agent. Alternatively, any enantiomer of a compound of the formulas (I) and (II) may be obtained by stereospecific synthesis using optically pure starting materials or reagents of known configuration.

The compounds of formulas (I) and (II) of the present invention can be prepared according to the procedures of the following Schemes and Examples, using appropriate materials and are further exemplified by the following specific examples. Moreover, by utilizing the procedures described herein, in conjunction with ordinary skills in the art, additional compounds of the present invention claimed herein can be readily prepared. The compounds illustrated in the examples are not, however, to be construed as forming the only genus that is considered as the invention. The Examples further illustrate details for the preparation of the compounds of the present invention. Those skilled in the art will readily understand that known variations of the conditions and processes of the following preparative procedures can be used to prepare these compounds. The instant compounds are generally isolated in the form of their pharmaceutically acceptable salts, such as those described previously. The free amine bases corresponding to the isolated salts can be generated by neutralization with a suitable base, such as aqueous sodium hydrogencarbonate, sodium carbonate, sodium hydroxide and potassium hydroxide, and extraction of the liberated amine free base into an organic solvent followed by evaporation. The amine free base isolated in this manner can be further converted into another pharmaceutically acceptable salt by dissolution in an organic solvent followed by addition of the appropriate acid and subsequent evaporation, precipitation or crystallization. All temperatures are degrees Celsius. Mass spectra (MS) were measured by electron-spray ion-mass spectroscopy.

In the schemes, preparations and examples below, various reagent symbols and abbreviations have the following meanings:

Boc	tert-butoxycarbonyl
DCM	dichloromethane
DIPEA	diisopropylethylamine
DMAP	4-dimethylaminopyridine
DMF	N,N-dimethylformamide
EDC	1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride
Et	ethyl
EtOAc	ethyl acetate
Fmoc	9-fluorenylmethyl-carbamate
HOAc	acetic acid
HOAt	1-hydroxy-7-azabenzotriazole
HOBt	1-hydroxybenzotriazole
h	hour(s)
NMM	N-methylmorpholine
Phe	phenylalanine
TFA	trifluoroacetic acid
TEA	triethylamine
THF	tetrahydrofuran
Tic	1,2,3,4-tetrahydroisoquinoline-3-carboxylic acid
TMOF	trimethylorthoformate
Z	benzyloxycarbonyl

Reaction Scheme 1: Coupling techniques**Technique 1****Technique 2****Technique 3**

In coupling technique 1, an appropriate "A moiety" (e.g., 4-cyclohexyl-4-[1,2,4]triazol-1-yl-methyl-piperidine) is coupled to "B moiety" (e.g., L-Boc-p-Cl-Phe-OH) in the presence of EDC/HOBt followed by Boc deprotection. The coupled AB compound is then coupled to an appropriate "C moiety" followed by deprotection of Boc group and salt formation. Alternatively, when "C moiety" is not protected with Boc group, the final compound can be obtained without the deprotection step.

In coupling technique 2, an appropriate "AB moiety" is coupled to an appropriate "C moiety" in the presence of EDC/HOBt followed by deprotection of Boc group and salt formation. Alternatively, when "C moiety" is not protected with Boc group, the final compound can be obtained without the deprotection step.

In coupling technique 3, an appropriate "BC moiety" is coupled to an appropriate "A moiety" in the presence of EDC/HOBt followed by deprotection of Boc group and salt formation. Alternatively, when "C moiety" is not protected with Boc group, the final compound can be obtained without the deprotection step.

For coupling of A with Boc-B-OH, EDC/HOAt, EDC/HOBt or DCC/HOBt can be used.

Generally, the starting material of Boc-protected piperazine or piperidine (A moiety) can be deprotected in the presence of TFA/CH₂Cl₂, HCl/EtOAc, HCl/dioxane or HCl in MeOH/Et₂O with or without a cation scavenger, such as dimethyl sulfide (DMS) before being subjected to the coupling procedure. It can be free-based before being subjected to the coupling procedure or in some cases used as the salt.

A suitable solvent, such as CH₂Cl₂, DMF, THF or a mixture of the above solvents, can be used for the coupling procedure. A suitable base includes triethylamine (TEA), diisopropylethylamine (DIPEA), N-methylmorpholine (NMM), collidine or 2,6-lutidine.

A base may not be needed when EDC/HOBt is used.

Generally after the reaction is completed, the reaction mixture can be diluted with an appropriate organic solvent, such as EtOAc, CH₂Cl₂ or Et₂O, which is then washed with aqueous solutions, such as water, HCl, NaHSO₄, bicarbonate, NaH₂PO₄, phosphate buffer (pH 7), brine or any combination thereof. The reaction mixture can be concentrated and then be partitioned between an appropriate organic solvent and an aqueous solution. The reaction mixture can be concentrated and subjected to chromatography without aqueous workup.

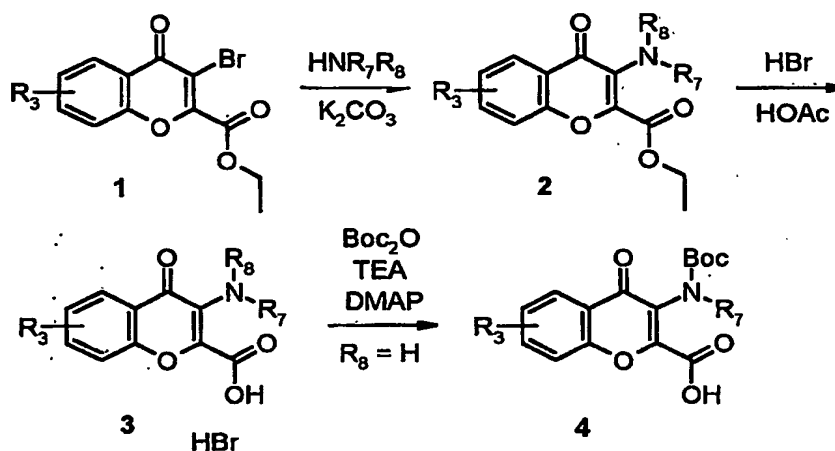
Protecting groups such as Boc, Z, Fmoc and CF₃CO can be deprotected in the presence of H₂/Pd-C, TFA/DCM, HCl/EtOAc, HCl/dioxane, HCl in MeOH/Et₂O, NH₃/MeOH or TBAF, with or without a cation scavenger, such as thioanisole, ethane thiol and dimethyl sulfide (DMS). The deprotected amines can be used as the resulting salt or are free-based by dissolving in DCM and washing with aqueous bicarbonate or aqueous NaOH. The deprotected amines can also be free-based by ion exchange chromatography.

The "A moieties" can be prepared as described in the corresponding literature:

4-Cyclohexyl-4-[1,2,4]triazol-1-ylmethyl-piperidine (WO0074679), 4-cyclohexyl-piperidine-4-carboxylic acid tert-butylamide (WO0170708), 2-piperazin-1-yl-benzonitrile, 1-(2-nitrophenyl)-piperazine, 4-bromo-2-piperazin-1-yl-benzonitrile and N-(2-piperazin-1-yl-phenyl)-isobutyramide (WO02059108), 1,2-dihydro-1-methanesulfonylspiro-[3H-indole-3,4'-piperidine] (US005536716).

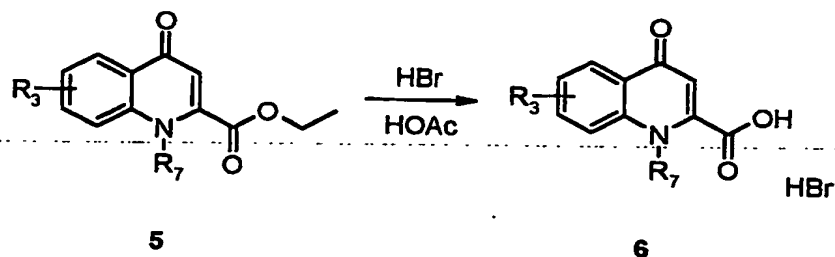
Reaction Schemes for Preparation of "C moiety"

Reaction Scheme 2: Chromenecarboxylic acids



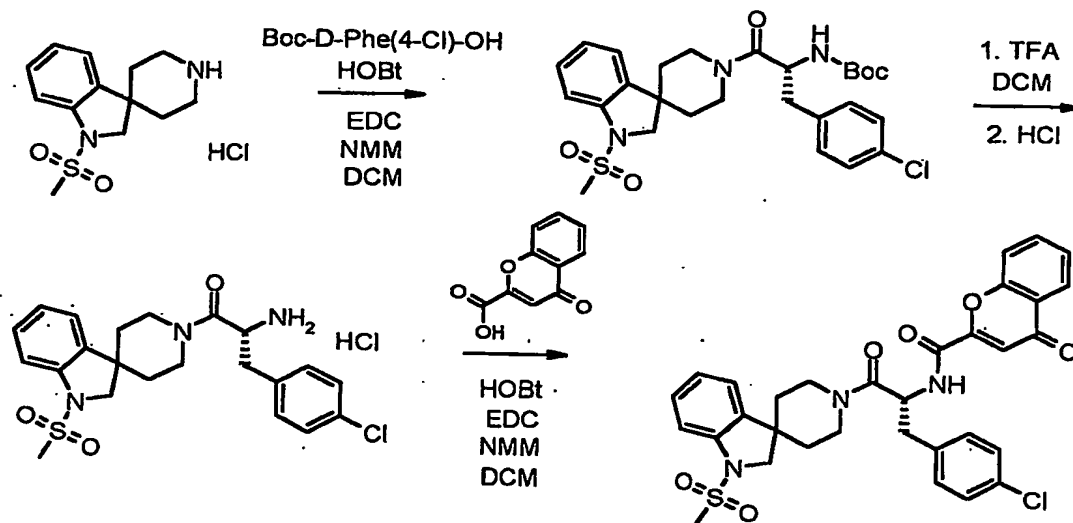
As shown in Reaction Scheme 2, ethyl 3-bromo-4-oxochromene-2-carboxylate **1** (*J. Chem. Soc. Perkin Trans. I* 1986, 1643-1649) can be reacted with amines, with or without a base such as K₂CO₃, in an appropriate solvent such as MeCN, to form products **2** which are subsequently treated with a reagent such as HBr/HOAc, to form carboxylic acids **3**. When R₈ is hydrogen, the free amine can be protected with a reagent such as Boc₂O in the presence of TEA and DMAP in an appropriate solvent.

Reaction Scheme 3: 4-Oxo-1,4-dihydro-quinoline-2-carboxylic acids

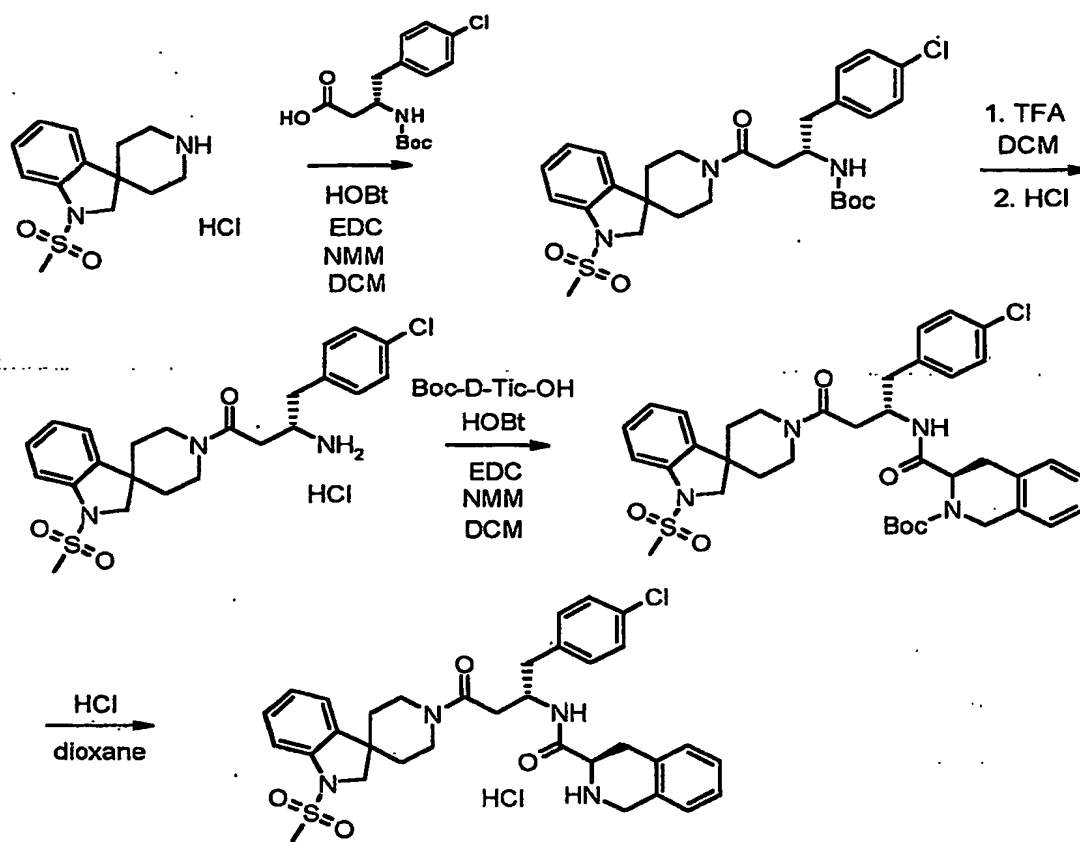


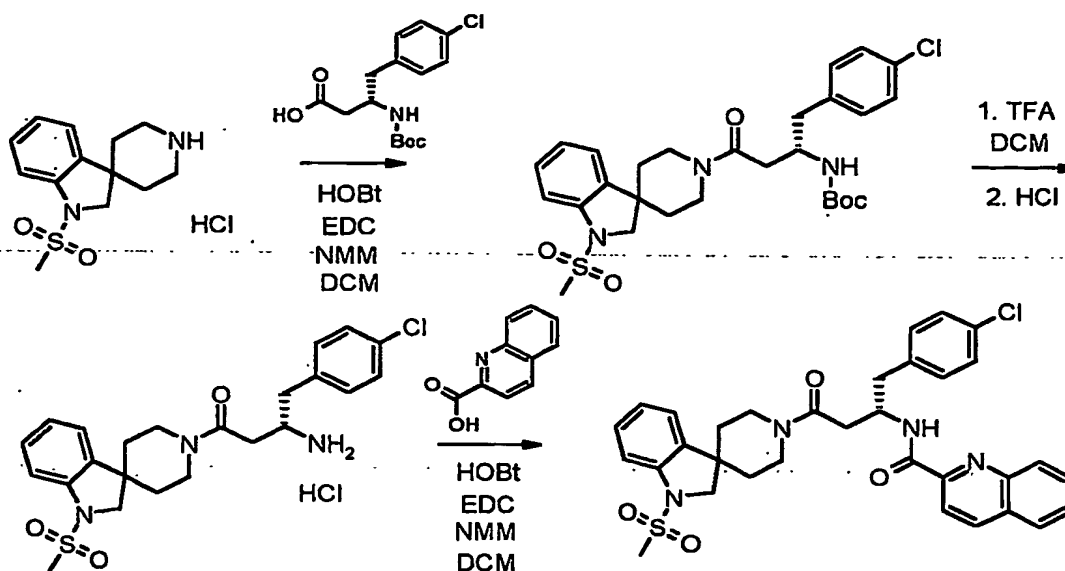
As shown in Reaction Scheme 3, ethyl 4-oxo-1,4-dihydro-quinoline-2-carboxylates **5** (*Bioorg. Med. Chem. Lett.* 2000, **10**, 1487-1490) can be converted into the corresponding acids **6** by an appropriate reactant such as HBr/HOAc.

The following describes the detailed examples of the invention



Synthesis Scheme for Example 1

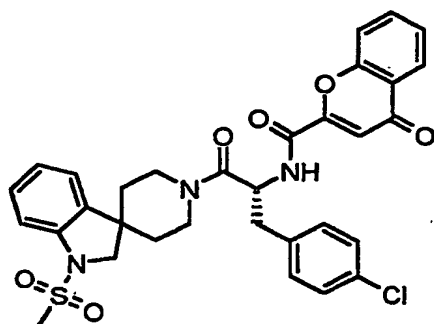
**Synthesis Scheme for Example 11**



Synthesis Scheme for Example 23

The following examples are provided to illustrate the invention and are not limiting the scope of the invention in any manner.

Example 1:



To chromone-2-carboxylic acid (17 mg) in DCM (2 ml) was added intermediate 1b) (39 mg), N-methylmorpholine (14 μ l), HOBT (14 mg) and stirred for 20 min. EDC (23 mg) was added

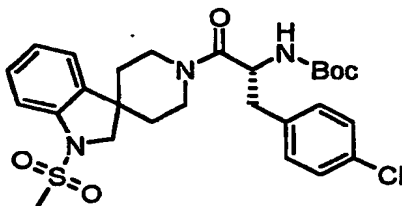
and stirring was continued for 1 h. An additional amount of N-methylmorpholine (8 μ l) was added and stirred overnight. The reaction mixture was poured into water (5 ml) and the organic phase was separated. The aqueous phase was extracted two times with DCM. The combined organic phases were washed with 0.5 N HCl and saturated sodium bicarbonate solution, dried over Na_2SO_4 and concentrated to yield the product which was purified by column chromatography.

colorless solid

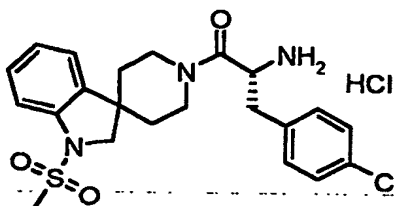
$R_f = 0.52$ (EtOAc); Mp. 137 - 147 $^{\circ}\text{C}$.

The required intermediates can be synthesized in the following way:

Intermediate 1a):



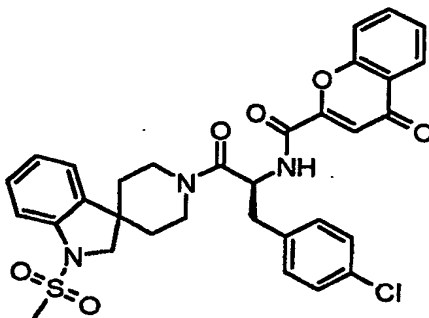
To Boc-D-4-chlorophenylalanine (82 mg) in DCM (5 ml) was added the amine hydrochloride (preparation in US005536716) (62 mg), N-methylmorpholine (42 μ l), HOBt (48 mg) and stirred for 20 min. EDC (72 mg) was added and stirring was continued for 1 h. An additional amount of N-methylmorpholine (20 μ l) was added and stirred overnight. The reaction mixture was poured into water (5 ml) and the organic phase was separated. The aqueous phase was extracted two times with DCM. The combined organic phases were washed with 0.5 N HCl and saturated sodium bicarbonate solution, dried over Na_2SO_4 and concentrated in vacuo. Purification by column chromatography yielded the title compound.

Intermediate 1b):

To the Boc-protected amine from 1a) (86 mg) in DCM (5 ml) was added TFA (1 ml) and stirred at room temperature for 90 min. Additional TFA (1 ml) was added and stirred for 10 min. The reaction mixture was diluted with DCM (10 ml) and carefully basified by pouring into 10% aqueous sodium carbonate solution (20 ml). The organic layer was separated and the aqueous layer was further extracted three times with DCM. The combined organics were washed with water and brine, dried over Na_2SO_4 , concentrated to give a white solid.

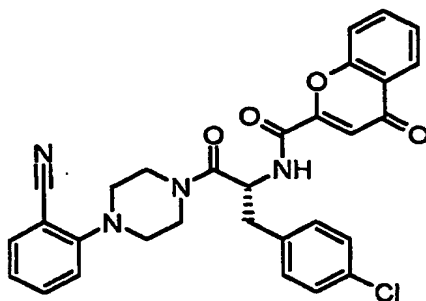
For prolonged storage, the free base was converted into the corresponding hydrochloride. The free base was dissolved in DCM (5 ml) and app. 1 M HCl in ether (10 ml) was added. The precipitate was filtered and the residue was washed three times with ether and dried under reduced pressure to yield the desired compound.

The following examples can be prepared in a similar way:

Example 2:

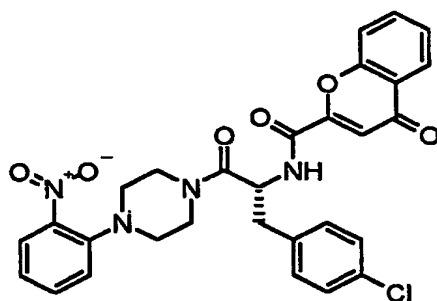
colorless solid

R_f = 0.52 (EtOAc); Mp. 139 - 160 °C.

Example 3:

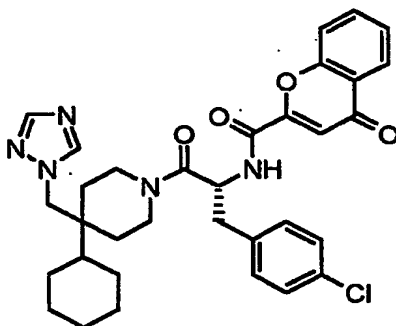
white solid

$R_f = 0.61$ (EtOAc); Mp. 94 °C.

Example 4:

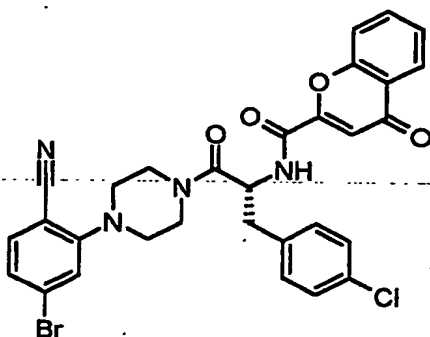
yellow solid

$R_f = 0.64$ (EtOAc); Mp. 94 °C.

Example 5:

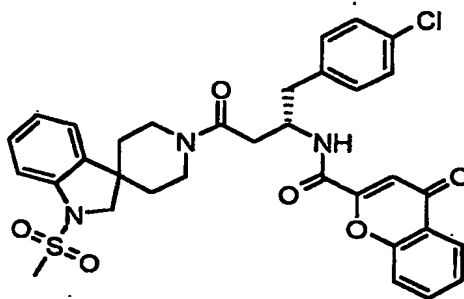
white solid

$R_f = 0.67$ (EtOAc/ethanol 3:1); Mp. 117 - 126 °C.

Example 6:

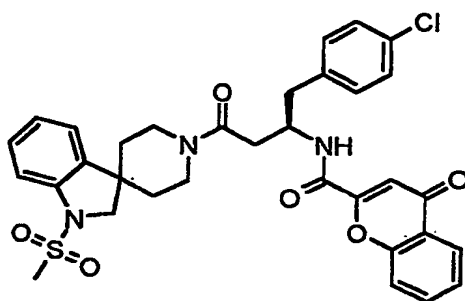
white solid

$R_f = 0.61$ (EtOAc); Mp. 119 - 126 °C.

Example 7:

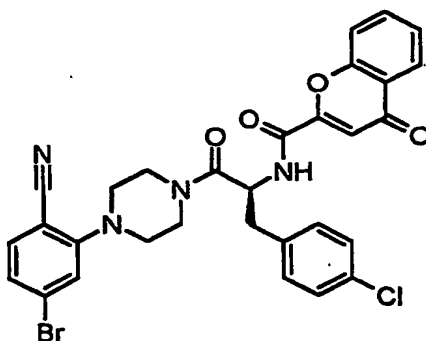
white solid

$R_f = 0.74$ (EtOAc/ethanol 3:1); Mp. 134 - 136 °C.

Example 8:

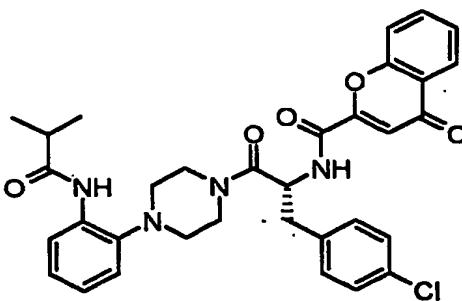
white solid

$R_f = 0.74$ (EtOAc/ethanol 3:1); Mp. 130 - 135 °C.

Example 9:

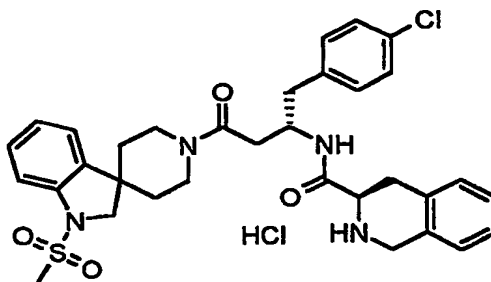
white solid

$R_f = 0.71$ (EtOAc); Mp. 147 - 156 °C.

Example 10:

white solid

$R_f = 0.70$ (EtOAc); Mp. 149 - 158 °C.

Example 11:

To Boc-protected intermediate 11c) (32 mg) was added hydrogen chloride, 4.0 M sol. in 1,4-dioxane (10 ml) and the solution was stirred for 90 min at room temperature. The solvent

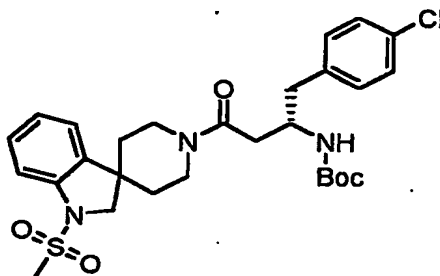
was removed under reduced pressure. The residue was dissolved in DCM and treated with diethyl ether. The precipitate was filtered off to yield the title compound as a solid.

white solid

Mp. 160 - 175 °C.

The required intermediates can be synthesized in the following way:

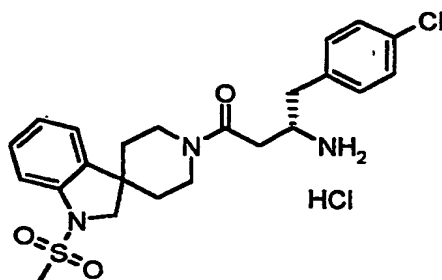
Intermediate 11a):



To Boc-(S)-3-amino-(4-chloro-phenyl)-butyric acid (170 mg) in DCM (6 ml) was added 1,2-dihydro-1-methanesulfonylspiro-[3H-indole-3,4'-piperidine] hydro-chloride (179 mg), N-methylmorpholine (83 μ l), HOBt (140 mg) and stirred for 25 min. EDC (144 mg) was added and stirring was continued for 1 h. An additional amount of N-methylmorpholine (30 μ l) was added and stirred overnight. The reaction mixture was poured into water (5 ml) and the organic phase was separated. The aqueous phase was extracted two times with DCM. The combined organic phases were washed with 0.5 N HCl and saturated sodium bicarbonate solution, dried over Na₂SO₄ and concentrated. The crude product was slurried in ethanol/ethyl acetate and filtrated to yield the desired compound after filtration.

white solid

R_f = 0.47 (EtOAc).

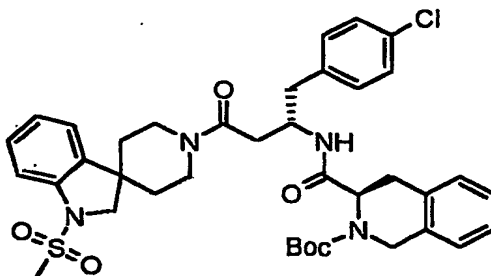
Intermediate 11b):

To intermediate 11a) (210 mg) in DCM (5 ml) was added TFA (1 ml) and stirred at room temperature for 2.5 h. Additional TFA (1 ml) was added and stirred for 1 h. The reaction mixture was diluted with DCM (5 ml) and carefully basified by pouring it into 10% aqueous sodium carbonate solution (10 ml). The organic layer was separated and the aqueous layer was further extracted twice with DCM. The combined organics were washed with water and brine, dried over Na_2SO_4 and concentrated to give colorless glassy solid.

The crude product was dissolved in DCM (5 ml) and app. 1 M HCl in ether (10 ml) was added. The precipitate was filtered and the residue was washed three times with ether and dried under reduced pressure to yield the title compound.

white solid

Mp. 160 - 175°C.

Intermediate 11c):

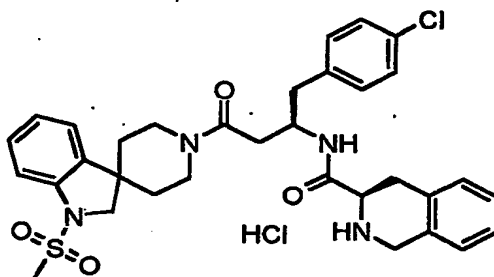
To intermediate 11b) (23 mg) and DCM (1 ml) was added (R)-Boc-1,2,3,4-tetrahydroisoquinoline-3-carboxylic acid (16 mg), HOBt (9 mg) and EDC (15 mg) and stirred overnight. The reaction mixture was poured into water (5 ml) and the organic layer was separated. The aqueous layer was extracted twice with DCM. The combined organics were washed with 0.5 N HCl (5 ml) and saturated sodium bicarbonate solution, dried over Na_2SO_4 and concentrated. The crude product was purified by column chromatography.

colorless solid

$R_f = 0.76$ (EtOAc/ethanol 3:1).

The following examples can be prepared in a similar way:

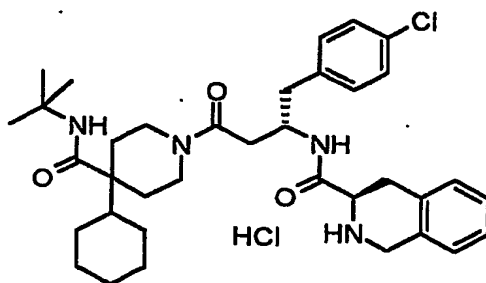
Example 12:

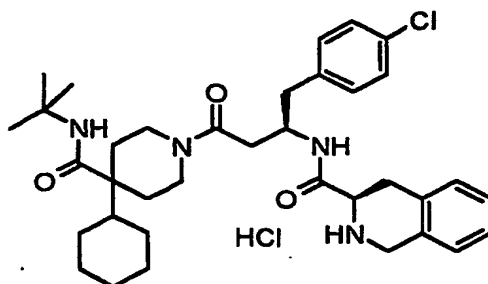
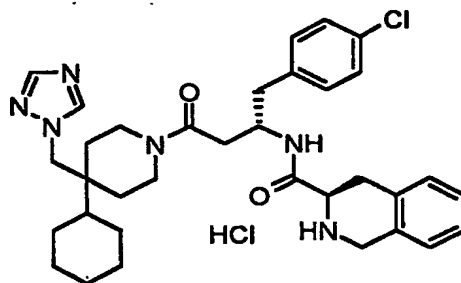
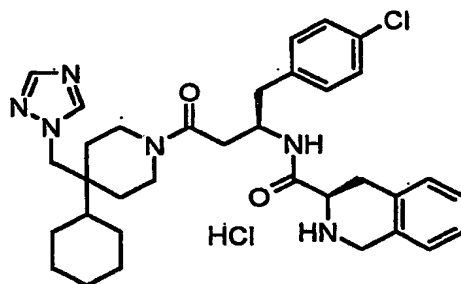
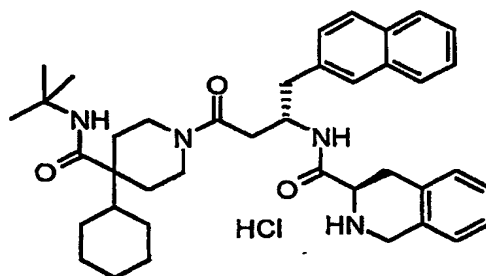


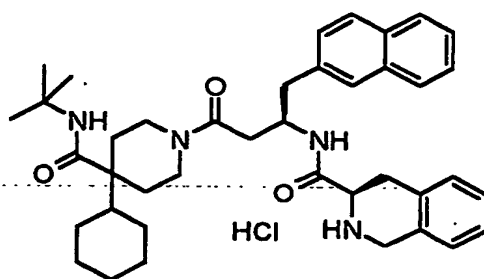
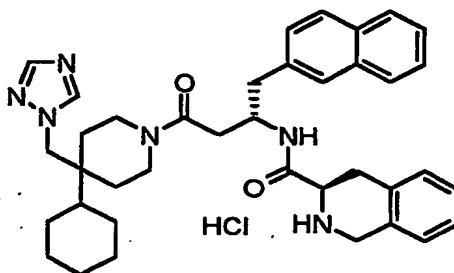
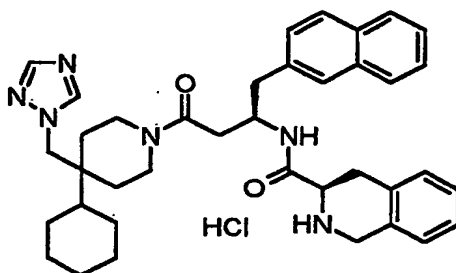
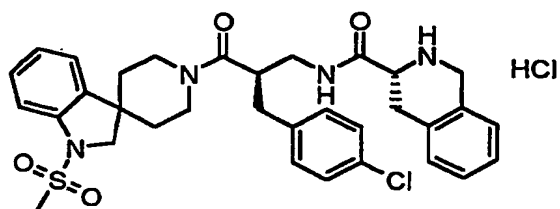
white solid

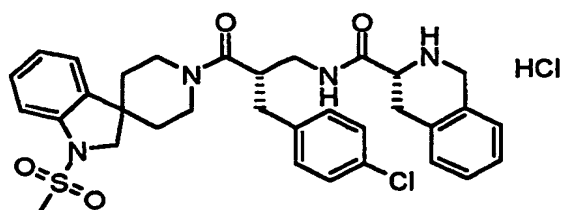
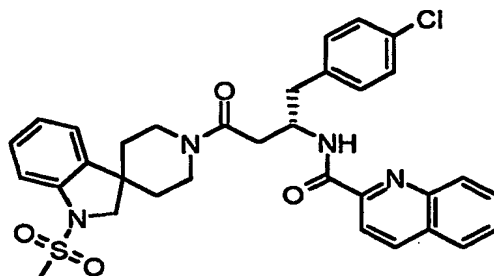
Mp. 162 - 177 °C.

Example 13:



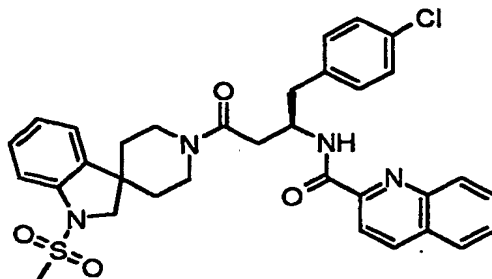
Example 14:**Example 15:****Example 16:****Example 17:**

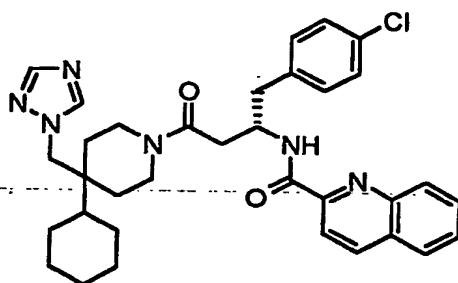
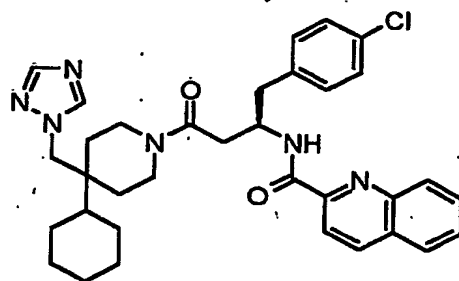
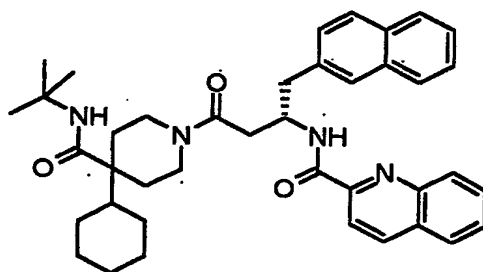
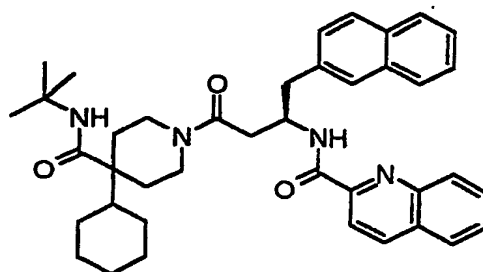
Example 18:**Example 19:****Example 20:****Example 21:**

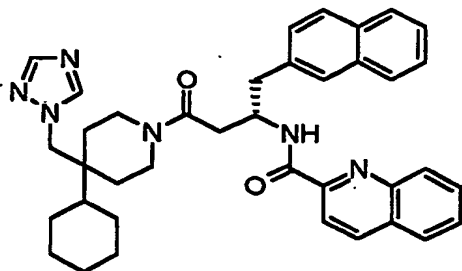
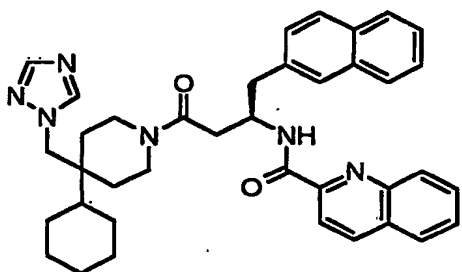
Example 22:**Example 23:**

To intermediate 11b) (23 mg) and DCM (1 ml) was added quinaldic acid (52 mg), HOBT (9 mg) and EDC (15 mg) and stirred overnight. The reaction mixture was poured into water (5 ml) and the organic layer was separated. The aqueous layer was extracted twice with DCM. The combined organics were washed with 0.5 N HCl (5 ml) and saturated sodium bicarbonate solution, dried over Na_2SO_4 and concentrated. The crude product was purified by column chromatography.

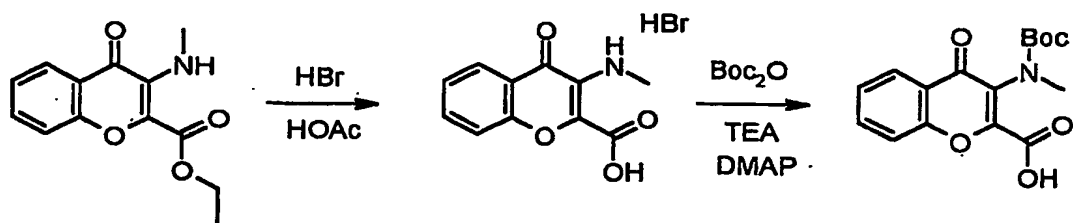
The following examples can be prepared in a similar way:

Example 24:

Example 25:**Example 26:****Example 27:****Example 28:**

Example 29:**Example 30:**

Preparation of the carboxylic acids:

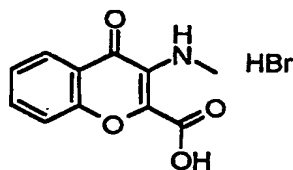


Synthesis Scheme for Carboxylic Acid 1

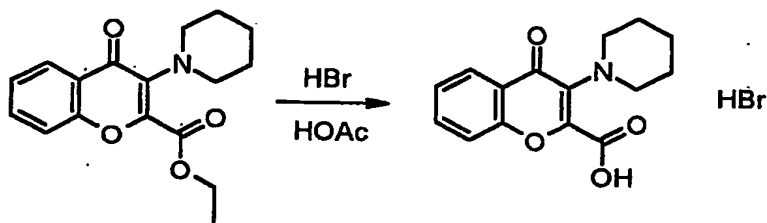
Carboxylic Acid 1:

To a solution of intermediate CA1a) (0.4 g) in THF (10 ml) was added TEA (670 μ l), DMAP (20 mg) and Boc_2O (384 mg). The reaction mixture was stirred overnight. The solvent was removed under reduced pressure and the residue was dissolved in ethyl acetate. The solution was extracted with water, 1 M HCl and sat. NaHCO_3 and dried over Na_2SO_4 . The solvent was removed under reduced pressure to yield the title compound.

Intermediate CA1a):



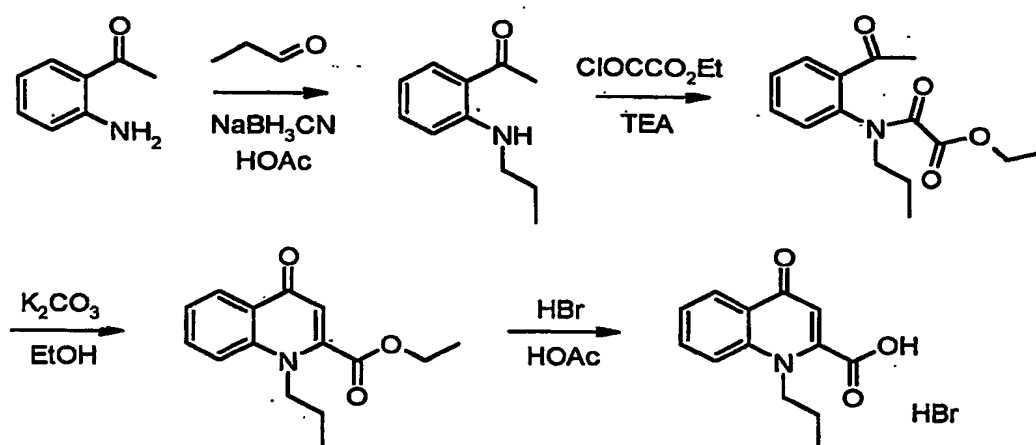
Ethyl 3-methylamino-4-oxochromene-2-carboxylate (0.8 g) was hydrolyzed by heating with hydrobromic acid (4 ml) and acetic acid (3 ml) for 4 h to give the desired compound after evaporation of the solvent.



Synthesis Scheme for Carboxylic Acid 2

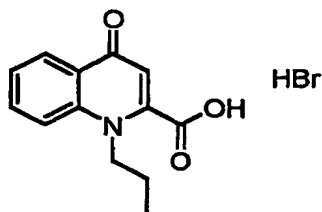
Carboxylic Acid 2:

Ethyl 3-piperidino-4-oxochromene-2-carboxylate (0.8 g) was hydrolyzed by heating with hydrobromic acid (4 ml) and acetic acid (3 ml) for 4 h to give the desired compound after evaporation of the solvent.

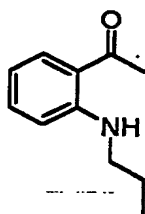


Synthesis Scheme for Carboxylic Acid 3

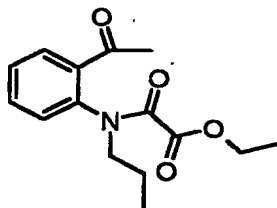
Carboxylic Acid 3:



Intermediate CA3c) (0.1 g) was hydrolyzed by heating with hydrobromic acid (2 ml) and acetic acid (1.5 ml) for 3 h to give the desired compound after evaporation of the solvent.

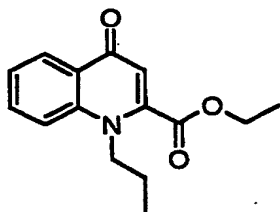
Intermediate CA3a):

To a solution of 2'-aminoacetophenone (709 mg) in methanol (10 ml) was added propionaldehyde (580 μ l) and TMOF (482 μ l) and the solution was stirred overnight. The volatiles were removed under reduced pressure and the residue was redissolved in methanol (10 ml). Acetic acid (115 μ l) and sodium cyanoborohydride (126 mg) were added and the reaction was stirred overnight. After basification with 1 M NaOH the volatiles were removed under reduced pressure. The residue was dissolved in ethyl acetate and washed with water and brine. The organic phase was dried over Na₂SO₄ and the solvent was removed under reduced pressure to yield the title compound.

Intermediate CA3b):

To a solution of intermediate CA3a) (681 mg) in dry THF (10 ml) was added TEA (670 μ l) and the mixture was cooled to 0°C. At this temperature, ethyl oxalyl chloride (470 μ l) was added dropwise. The reaction mixture was stirred for 4 h at room temperature. The volatiles were removed under reduced pressure and the residue was dissolved in ethyl acetate. The solution was washed with water and sat. NaHCO₃ and brine and dried over Na₂SO₄ to yield the desired compound.

Intermediate CA3c):



Intermediate CA3b) (555 mg) was dissolved in ethanol (10 ml). K_2CO_3 (276 mg) was added and the reaction mixture was stirred overnight. The reaction mixture was filtrated and the solvent was removed to yield the title compound.

BIOLOGICAL ASSAYS

A. Binding Assay

A membrane binding assay is used to identify competitive inhibitors of fluorescence labeled NDP-alpha-MSH binding to HEK293 cell membrane preparations, expressing human melanocortin receptors.

The test compound or unlabeled NDP-alpha-MSH is dispensed at varying concentrations to a 384 well microtiter plate. Fluorescence labeled NDP-alpha-MSH is dispensed at a single concentration, followed by addition of membrane preparations. The plate is incubated for 60 to 90 min at room temperature.

The degree of fluorescence polarization is determined with a fluorescence polarization microplate reader.

B. Functional Assay

A functional cellular assay, based on competition between unlabeled cAMP and a fixed quantity of fluorescence labeled cAMP for a limited number of binding sites on a cAMP specific antibody, is used to discriminate melanocortin receptor agonists from antagonists by fluorescence polarization.

HEK293 cells expressing one of the human melanocortin receptors are grown in 384 well microtiter plates and are stimulated at different concentrations of the test compound to effect cAMP production. Cells are lysed and a fluorescence labeled cAMP conjugate is dispensed followed by the addition of anti-cAMP antibody used to detect the produced cAMP. The plate is read on a fluorescence polarization microplate reader and the amount of cAMP produced, as a response to a test compound, is compared to the production of cAMP resulting from stimulation with NDP-alpha-MSH.

The ability of a compound to block cAMP production, in response to NDP-alpha-MSH, is measured to define antagonistic activity of a test compound. Percent inhibition is determined by comparing the amount of cAMP produced in the presence to that produced in the absence of test compound.

C. In Vivo Food Intake Models

1. Spontaneous Feeding Paradigm

Food intake in rats is measured after i.p. or p.o. administration of the test compound (see e.g. Chen, A.S. et al. Transgenic Res 2000 Apr;9(2):145-54).

2. Model of LPS and Tumor-Induced Cachexia

Prevention or amelioration of cachexia induced by either lipopolysaccharide (LPS) administration or by tumor growth is determined upon i.p. or p.o. administration of test

compounds to rats (see e.g. Marks, D.L.; Ling, N. and Cone, R.D. Cancer Res 2001 Feb 15;61(4):1432-8).

D. Rat Ex Copula Assay

Sexually mature male Caesarian Derived Sprague Dawley (CD) rats (over 60 days old) are used with the suspensory ligament surgically removed to prevent retraction of the penis back into the penile sheath during the ex copula evaluations. Animals receive food and water ad lib and are kept on a normal light/dark cycle. Studies are conducted during the light cycle.

1. Conditioning to Supine Restraint for Ex Copula Reflex Tests

This conditioning takes about 4 days. Day 1, the animals are placed in a darkened restrainer and left for 15 - 30 minutes. Day 2, the animals are restrained in a supine position in the restrainer for 15 - 30 minutes. Day 3, the animals are restrained in the supine position with the penile sheath retracted for 15 - 30 minutes. Day 4, the animals are restrained in the supine position with the penile sheath retracted until penile responses are observed. Some animals require additional days of conditioning before they are completely acclimated to the procedures; non-responders are removed from further evaluation. After any handling or evaluation, animals are given a treat to ensure positive reinforcement.

2. Ex Copula Reflex Tests

Rats are gently restrained in a supine position with their anterior torso placed inside a cylinder of adequate size to allow for normal head and paw grooming. For a 400 - 500 gram rat, the diameter of the cylinder is approximately 8 cm. The lower torso and hind limbs are restrained with a nonadhesive material (vetrap). An additional piece of vetrap with a hole in it, through which the glans penis will be passed, is fastened over the animal to maintain the preputial sheath in a retracted position. Penile responses will be observed, typically termed ex copula genital reflex tests. Typically, a series of penile erections will occur spontaneously

within a few minutes after sheath retraction. The types of normal reflexogenic erectile responses include elongation, engorgement, cup and flip. An elongation is classified as an extension of the penile body. Engorgement is a dilation of the glans penis. A cup is defined as an intense erection where the distal margin of the glans penis momentarily flares open to form a cup. A flip is a dorsiflexion of the penile body.

Baseline and or vehicle evaluations are conducted to determine how, and if, an animal will respond. Some animals have a long duration until the first response while others are non-responders altogether. During this baseline evaluation latency to first response, number and type of responses are recorded. The testing time frame is 15 minutes after the first response.

After a minimum of 1 day between evaluations, these same animals are administered the test compound at 20 mg/kg and evaluated for penile reflexes. All evaluations are videotaped and scored later. Data are collected and analyzed using paired 2 tailed t-tests to compared baseline and/or vehicle evaluations to drug treated evaluations for individual animals. Groups of a minimum of 4 animals are utilized to reduce variability.

Positive reference controls are included in each study to assure the validity of the study. Animals can be dosed by a number of routes of administration depending on the nature of the study to be performed. The routes of administration includes intravenous (IV), intraperitoneal (IP), subcutaneous (SC) and intracerebral ventricular (ICV).

E. Models of Female Sexual Dysfunction

Rodent assays relevant to female sexual receptivity include the behavioral model of lordosis and direct observations of copulatory activity. There is also a urethrogenital reflex model in anesthetized spinally transected rats for measuring orgasm in both male and female rats. These and other established animal models of female sexual dysfunction are described in McKenna KE et al, A Model For The Study of Sexual Function In Anesthetized Male And Female Rats, Am. J. Physiol. (Regulatory Integrative Comp. Physiol 30): R1276-R1285, 1991; McKenna KE et al, Modulation By Peripheral Serotonin of The Threshold For Sexual

Reflexes In Female Rats, Pharm. Bioch. Behav., 40:151-156, 1991; and Takahashi LK et al, Dual Estradiol Action In The Diencephalon And The Regulation of Sociosexual Behavior In Female Golden Hamsters, Brain Res., 359:194-207, 1985.

Representative compounds of the present invention were tested and found to bind to the melanocortin-4 receptor. These compounds were generally found to have IC50 values less than 2 μ M. Representative compounds of the present invention were also tested in the functional assay and found generally to activate the melanocortin-4 receptor with EC50 values less than 1 μ M.

Examples of a Pharmaceutical Composition

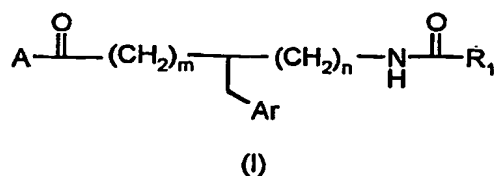
As a specific embodiment of an oral composition of a compound of the present invention, 25 mg of Example 11 is formulated with sufficient finely divided lactose to provide a total amount of 580 to 590 mg to fill a size 0 hard gelatin capsule.

As another specific embodiment of an oral composition of a compound of the present invention, 35 mg of Example 22 is formulated with sufficient finely divided lactose to provide a total amount of 580 to 590 mg to fill a size 0 hard gelatin capsule.

While the invention has been described and illustrated in reference to certain preferred embodiments thereof, those skilled in the art will appreciate that various changes, modifications and substitutions can be made therein without departing from the spirit and scope of the invention. For example, effective dosages, other than the preferred doses as set forth above, may be applicable as a consequence of the specific pharmacological responses observed and may vary depending upon the particular active compound selected, as well as from the type of formulation and mode of administration employed, and such expected variations or differences in the results are contemplated in accordance with the objects and practices of the present invention. It is intended, therefore, that the invention be limited only by the scope of the claims which follow and that such claims be interpreted as broadly as is reasonable.

CLAIMS

1. A compound of structural formula (I):

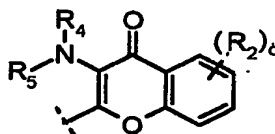
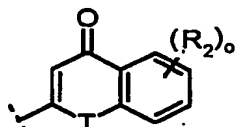


or a pharmaceutically acceptable salt or a solvate thereof, wherein

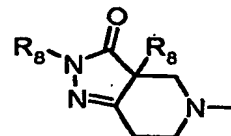
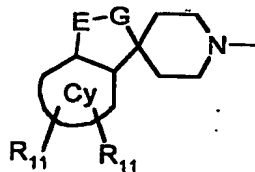
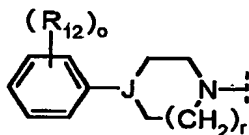
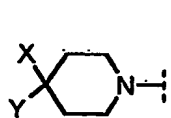
Ar is:

aryl or heteroaryl which may both be substituted;

R₁ is:



A is:



R₂ is independently:

hydrogen,
halo,
alkyl,
haloalkyl,
alkoxy,

(D)-cycloalkyl,
(D)-aryl,
(D)-heteroaryl,
(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and
wherein aryl, heteroaryl, heterocyclyl, alkyl and cycloalkyl are substituted or unsubstituted;

R₄ and R₅ are each independently:

hydrogen,
alkyl or

(D)-cycloalkyl, or

R₄ and R₅ together with the nitrogen to which they are attached form a 5- to 8-membered ring,
wherein alkyl and cycloalkyl are unsubstituted or substituted;

R₈ is independently:

hydrogen,
alkyl,
(D)-aryl or
(D)-cycloalkyl;

R₉ is independently:

hydrogen,
alkyl,
(D)-aryl,
(D)-heteroaryl or
(D)-cycloalkyl;

R₁₀ is independently:

R₉,
(D)-heterocyclyl,
(D)-N(Y)₂,

(D)-NH-heteroaryl or

(D)-NH-heterocyclyl,

wherein aryl, heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are substituted or unsubstituted, or

two R₁₀ groups together with the atoms to which they are attached form a 5- to 8-membered mono- or bi-cyclic ring system;

R₁₁ is:

hydrogen,

halo,

alkyl,

alkoxy,

C≡N,

CF₃ or

OCF₃;

R₁₂ is independently:

hydrogen,

hydroxy,

cyano,

nitro,

halo,

alkyl,

alkoxy,

haloalkyl,

(D)-C(O)R₁₄,

(D)-C(O)OR₁₄,

(D)-C(O)SR₁₄,

(D)-C(O)-heteroaryl,

(D)-C(O)-heterocyclyl,

(D)-C(O)N(R₁₄)₂,

(D)-N(R₁₄)₂,

(D)-NR₁₄COR₁₄,

(D)-NR₁₄CON(R₁₄)₂,

(D)-NR₁₄C(O)OR₁₄,

(D)-NR₁₄C(R₁₄)=N(R₁₄),

(D)-NR₁₄C(=NR₁₄)N(R₁₄)₂,

(D)-NR₁₄SO₂R₁₄,

(D)-NR₁₄SO₂N(R₁₄)₂,

(D)-NR₁₄(D)-heterocyclyl,

(D)-NR₁₄(D)-heteroaryl,

(D)-OR₁₄,

OSO₂R₁₄,

(D)-[O]_q(cycloalkyl),

(D)-[O]_q(D)aryl,

(D)-[O]_q(D)-heteroaryl,

(D)-[O]_q(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen when q=1),

(D)-SR₁₄,

(D)-SOR₁₄,

(D)-SO₂R₁₄ or

(D)-SO₂N(R₁₄)₂,

wherein alkyl, alkoxy, cycloalkyl, aryl, heterocyclyl and heteroaryl are substituted or unsubstituted;

R₁₄ is independently:

hydrogen,

alkyl,

haloalkyl,

(D)-cycloalkyl,

(D)-phenyl,

(D)-naphthyl,

(D)-heteroaryl,

(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and

wherein phenyl, naphthyl, heteroaryl, heterocyclyl, alkyl and cycloalkyl are substituted or unsubstituted;

X is:

alkyl,
 (D)-cycloalkyl,
 (D)-aryl,
 (D)-heteroaryl,
 (D)-heterocyclyl,
 (D)-C≡N,
 (D)-CON(R₉R₉),
 (D)-CO₂R₉,
 (D)-COR₉,
 (D)-NR₉C(O)R₉,
 (D)-NR₉CO₂R₉,
 (D)-NR₉C(O)N(R₉)₂,
 (D)-NR₉SO₂R₉,
 (D)-S(O)_pR₉,
 (D)-SO₂N(R₉)(R₉),
 (D)-OR₉,
 (D)-OC(O)R₉,
 (D)-OC(O)OR₉,
 (D)-OC(O)N(R₉)₂,
 (D)-N(R₉)(R₉) or
 (D)-NR₉SO₂N(R₉)(R₉),

wherein aryl, heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are unsubstituted or substituted;

Y is:

hydrogen,
 alkyl,
 (D)-cycloalkyl,
 (D)-aryl,

(D)-heterocyclyl or

(D)-heteroaryl,

wherein aryl, heteroaryl, alkyl, D and cycloalkyl are unsubstituted or substituted;

Cy is benzene, pyridine or cyclohexane;

D is a bond or alkylene;

E is CHCO_2Y , $\text{CHC}(\text{O})\text{N}(\text{Y})_2$, $\text{NSO}_2\text{R}_{10}$, $\text{CHN}(\text{Y})\text{COR}_{10}$, $\text{CHN}(\text{Y})\text{SO}_2\text{R}_{10}$, CHCH_2OY or $\text{CHCH}_2\text{heteroaryl}$;

G is D, CH-alkyl, O, C=O or SO_2 , with the proviso that when G is O, the ring atom E is carbon;

J is N or CH;

T is O or NR_4 ;

n is 0 - 2;

m is 0 - 2;

o is 0 - 3;

p is 0 - 2;

q is 0 or 1;

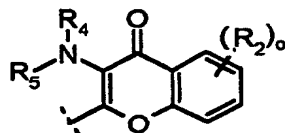
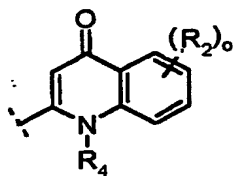
r is 1 or 2.

2. The compound of claim 1, wherein

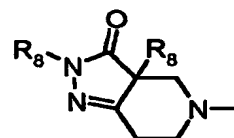
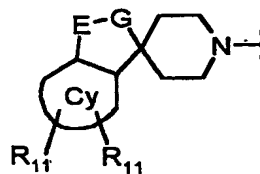
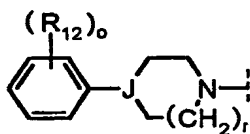
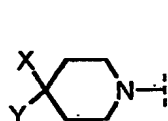
Ar is:

aryl which may be substituted with one to three substituents independently selected from the group consisting of cyano, nitro, perfluoroalkoxy, halo, alkyl, (D)-cycloalkyl, alkoxy and/or haloalkyl;

R₁ is:



A is:



R₂ is independently:

hydrogen,
hydroxy,
halo,
alkyl,
alkoxy,
haloalkyl or
(D)-cycloalkyl;

R₄ and R₅ are each independently:

hydrogen,
alkyl or
cycloalkyl, or

R₄ and R₅ together with the nitrogen to which they are attached form a 5- to 7-membered ring which may contain an additional heteroatom selected from O, S and NR₆;

R₆ is independently:

hydrogen,
alkyl,
C(O)alkyl,
(D)-aryl or
(D)-cycloalkyl;

R₈ is independently:

hydrogen,
alkyl or
(D)-aryl;

R₉ is independently:

hydrogen,
alkyl or
(D)-cycloalkyl;

R₁₀ is R₉;

R₁₁ is:

hydrogen,
halo,
alkyl or
C≡N;

R₁₂ is independently:

hydrogen,
hydroxy,
cyano,
nitro,
halo,
alkyl,
alkoxy,

haloalkyl,
 (D)-N(R₁₄)₂,
 (D)-NR₁₄COR₁₄,
 (D)-NR₁₄CON(R₁₄)₂,
 (D)-NR₁₄C(O)OR₁₄,
 (D)-NR₁₄C(R₁₄)=N(R₁₄),
 (D)-NR₁₄C(=NR₁₄)N(R₁₄)₂,
 (D)-NR₁₄SO₂R₁₄ or
 (D)-NR₁₄SO₂N(R₁₄)₂;

X is:

alkyl,
 (D)-cycloalkyl,
 (D)-aryl,
 (D)-heteroaryl,
 (D)-heterocyclyl,
 (D)-NHC(O)R₉,
 (D)-CO₂R₉ or
 (D)-CON(R₉R₉);

Y is:

hydrogen,
 alkyl,
 (D)-cycloalkyl,
 (D)-aryl,
 (D)-heterocyclyl or
 (D)-heteroaryl;

Cy is benzene or pyridine;

D is a bond or C₁ - C₄-alkylene;

E is NSO₂R₁₀, CHN(Y)COR₁₀ or CHN(Y)SO₂R₁₀;

G is D or CH-alkyl;

J is N or CH;

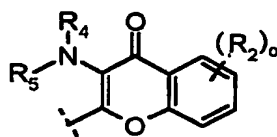
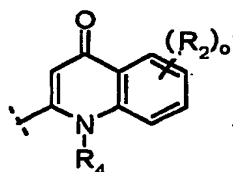
n is 0 or 1;
 m is 0 or 1;
 o is 0, 1 or 2;
 r is 1 or 2.

3. The compound of claim 1 or 2, wherein

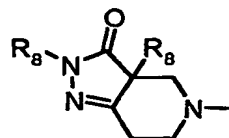
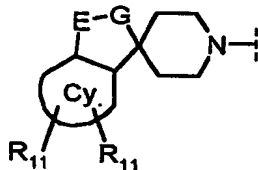
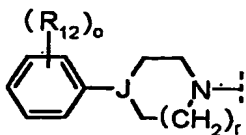
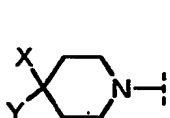
Ar is:

phenyl or naphthyl which may be substituted with one or two substituents independently selected from the group consisting of halo, alkyl, alkoxy and/or haloalkyl;

R₁ is:



A is:



R₂ is independently:

hydrogen,
 alkoxy,
 halo or
 alkyl;

R₄ and R₅ are each independently:

hydrogen or

alkyl, or

R₄ and R₅ together with the nitrogen to which they are attached form a 5- to 6-membered ring optionally containing an additional oxygen atom;

R₆ is hydrogen;

R₈ is independently:

alkyl or

(D)-aryl;

R₉ is alkyl;

R₁₀ is R₉;

R₁₁ is:

hydrogen,

halo and

C₁ - C₄-alkyl;

R₁₂ is independently:

cyano,

nitro,

halo,

alkyl,

(D)-N(R₁₄)₂,

(D)-NR₁₄COR₁₄,

(D)-NR₁₄CON(R₁₄)₂,

(D)-NR₁₄C(O)OR₁₄ or

(D)-NR₁₄SO₂R₁₄;

R_{14} is independently:

hydrogen,

halo,

alkyl,

alkoxy or

phenyl;

X is:

(D)-cycloalkyl,

(D)-heterocyclyl,

(D)-NHC(O) R_9 or

(D)-CON(R_9R_9);

Y is:

hydrogen,

alkyl,

(D)-cycloalkyl or

(D)-heterocyclyl;

Cy is benzene;

D is a bond or CH_2 ;

E is NSO_2R_{10} ;

G is D;

J is N or CH;

T is NR_4 ;

n is 0 or 1;

m is 0 or 1;

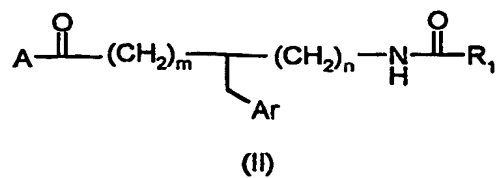
o is 0 or 1;

p is 0, 1 or 2;

q is 0 or 1;

r is 1.

4. A compound of structural formula (II):

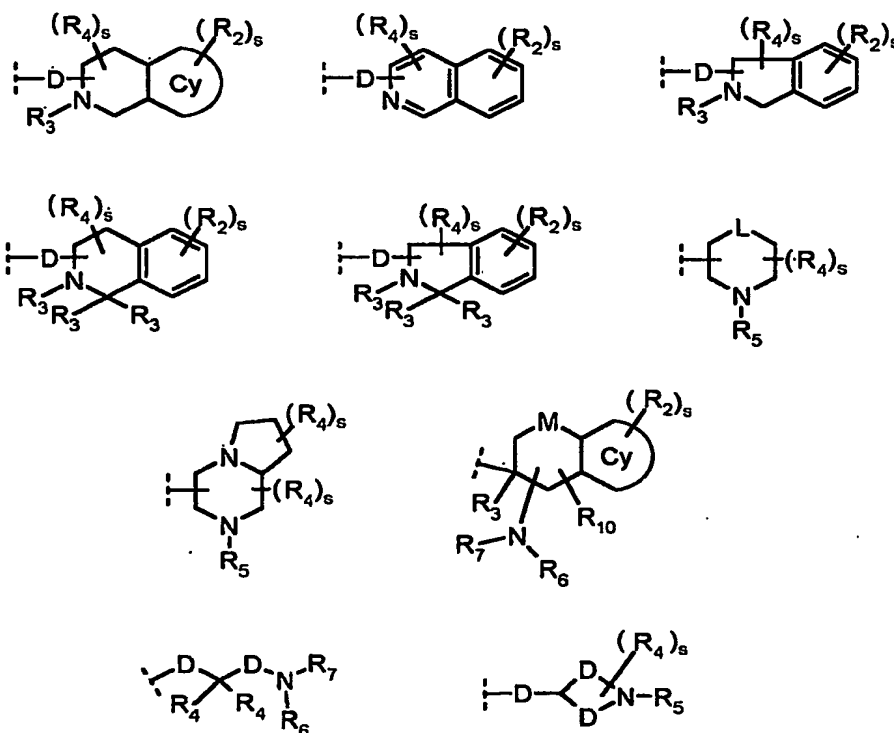


or a pharmaceutically acceptable salt or a solvate thereof, wherein

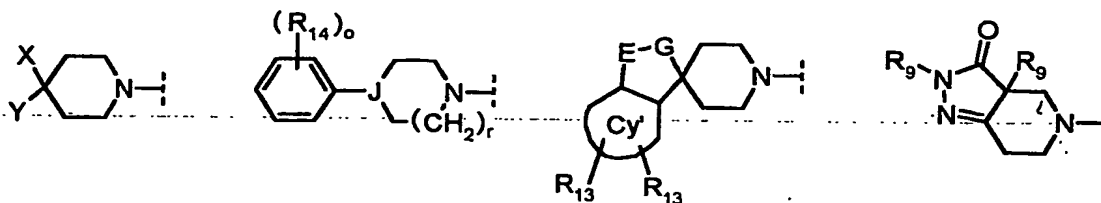
Ar is:

aryl or heteroaryl which may both be substituted;

R₁ is:



A is:



R_2 is independently:

hydrogen,

halo,

alkyl,

haloalkyl,

(D)-cycloalkyl,

(D)-aryl,

(D)-heteroaryl,

(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and

wherein aryl, heteroaryl, heterocyclyl, alkyl and cycloalkyl are substituted or unsubstituted;

R_3 is independently:

hydrogen,

alkyl,

SO_2 alkyl,

SO_2 aryl,

$C(O)$ alkyl,

(D)-aryl or

cycloalkyl;

R_4 is independently:

hydrogen,
alkyl,
(D)-aryl,
(D)-heteroaryl,
(D)- $N(R_6)_2$,
(D)- $NR_6C(O)alkyl$,
(D)- NR_6SO_2alkyl ,
(D)- $SO_2N(R_6)_2$,
(D)-(O) $_v$ alkyl,
(D)-(O) $_v$ (D) NR_6COR_6 ,
(D)-(O) $_v$ (D) $NR_7SO_2R_7$,
(D)-(O) $_v$ -heterocyclyl or
(D)-(O) $_v$ (alkyl)-heterocyclyl;

R_5 is independently:

hydrogen,
alkyl,
(D)-phenyl,
C(O)alkyl,
C(O)phenyl,
SO₂-alkyl or
SO₂-phenyl;

R_6 and R_7 are each independently:

hydrogen,
alkyl or
cycloalkyl, or

R_6 and R_7 together with the nitrogen to which they are attached form a 5- to 8-membered ring,
wherein alkyl and cycloalkyl are unsubstituted or substituted;

R₉ is independently:

hydrogen,
alkyl,
(D)-aryl or
cycloalkyl;

R₁₀ is hydrogen or alkyl;

R₁₁ is independently:

hydrogen,
alkyl,
(D)-aryl,
(D)-heteroaryl or
(D)-cycloalkyl;

R₁₂ is independently:

R₁₁,
(D)-heterocyclyl,
(D)-N(Y)₂,
(D)-NH-heteroaryl or
(D)-NH-heterocyclyl,

wherein aryl, heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are unsubstituted or substituted, or

two R₁₂ groups together with the atoms to which they are attached form a 5- to 8-membered mono- or bicyclic ring system;

R₁₃ is:

hydrogen,
halo,
alkyl,
alkoxy,
C≡N,
CF₃ or

OCF₃;

R₁₄ is independently:

hydrogen,

hydroxy,

cyano,

nitro,

halo,

alkyl,

alkoxy,

haloalkyl,

(D)-C(O)R₁₆,

(D)-C(O)OR₁₆,

(D)-C(O)SR₁₆,

(D)-C(O)-heteroaryl,

(D)-C(O)-heterocyclyl,

(D)-C(O)N(R₁₆)₂,

(D)-N(R₁₆)₂,

(D)-NR₁₆COR₁₆,

(D)-NR₁₆CON(R₁₆)₂,

(D)-NR₁₆C(O)OR₁₆,

(D)-NR₁₆C(R₁₆)=N(R₁₆),

(D)-NR₁₆C(=NR₁₆)N(R₁₆)₂,

(D)-NR₁₆SO₂R₁₆,

(D)-NR₁₆SO₂N(R₁₆)₂,

(D)-NR₁₆(D)-heterocyclyl,

(D)-NR₁₆(D)-heteroaryl,

(D)-OR₁₆,

OSO₂R₁₆,

(D)-[O]_q(cycloalkyl),

(D)-[O]_q(D)aryl,

(D)-[O]_q(D)-heteroaryl,

(D)-[O]_q(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen when q=1),

(D)-SR₁₆,

(D)-SOR₁₆,

(D)-SO₂R₁₆ or

(D)-SO₂N(R₁₆)₂,

wherein alkyl, alkoxy, cycloalkyl, aryl, heterocyclyl and heteroaryl are substituted or unsubstituted;

R₁₆ is independently:

hydrogen,

alkyl,

haloalkyl,

(D)-cycloalkyl,

(D)-aryl,

(D)-heteroaryl,

(D)-heterocyclyl (wherein heterocyclyl excludes a heterocyclyl containing a single nitrogen), and

wherein aryl, heteroaryl, heterocyclyl, alkyl and cycloalkyl are substituted or unsubstituted;

Cy is:

aryl,

heteroaryl,

heterocyclyl or

carbocyclyl;

X is:

alkyl,

(D)-cycloalkyl,

(D)-aryl,

(D)-heteroaryl,

(D)-heterocyclyl,

(D)-C \equiv N,
 (D)-CON(R₁₁R₁₁),
 (D)-CO₂R₁₁,
 (D)-COR₁₁,
 (D)-NR₁₁C(O)R₁₁,
 (D)-NR₁₁CO₂R₁₁,
 (D)-NR₁₁C(O)N(R₁₁)₂,
 (D)-NR₁₁SO₂R₁₁,
 (D)-S(O)_pR₁₁,
 (D)-SO₂N(R₁₁)(R₁₁),
 (D)-OR₁₁,
 (D)-OC(O)R₁₁,
 (D)-OC(O)OR₁₁,
 (D)-OC(O)N(R₁₁)₂,
 (D)-N(R₁₁)(R₁₁) or
 (D)-NR₁₁SO₂N(R₁₁)(R₁₁),

wherein aryl, heteroaryl, alkyl, D, cycloalkyl and heterocyclyl are unsubstituted or substituted;

Y is:

hydrogen,
 alkyl,
 (D)-cycloalkyl,
 (D)-aryl,
 (D)-heterocyclyl or
 (D)-heteroaryl,

wherein aryl, heteroaryl, alkyl, D and cycloalkyl are unsubstituted or substituted;

Cy' is benzene, pyridine or cyclohexane;

D is a bond or alkylene;

E is CHCO_2Y , $\text{CHC}(\text{O})\text{N}(\text{Y})_2$, $\text{NSO}_2\text{R}_{10}$, $\text{CHN}(\text{Y})\text{COR}_{12}$, $\text{CHN}(\text{Y})\text{SO}_2\text{R}_{12}$, CHCH_2OY or $\text{CHCH}_2\text{heteroaryl}$;

G is D, CH-alkyl, O, C=O or SO_2 with the proviso that when G is O, the ring atom E is carbon;

J is N or CH;

L is O, S or NR_5 ;

M is a bond, O, $\text{S}(\text{O})_u$, NR_5 or CH_2 ;

n is 0 - 2, unless m is 0, then n is 1 or 2;

m is 0 - 2, unless n is 0, then m is 1 or 2;

o is 0 - 3;

p is 0 - 2;

q is 0 or 1;

r is 1 or 2;

s is 0 - 5;

v is 0 or 1;

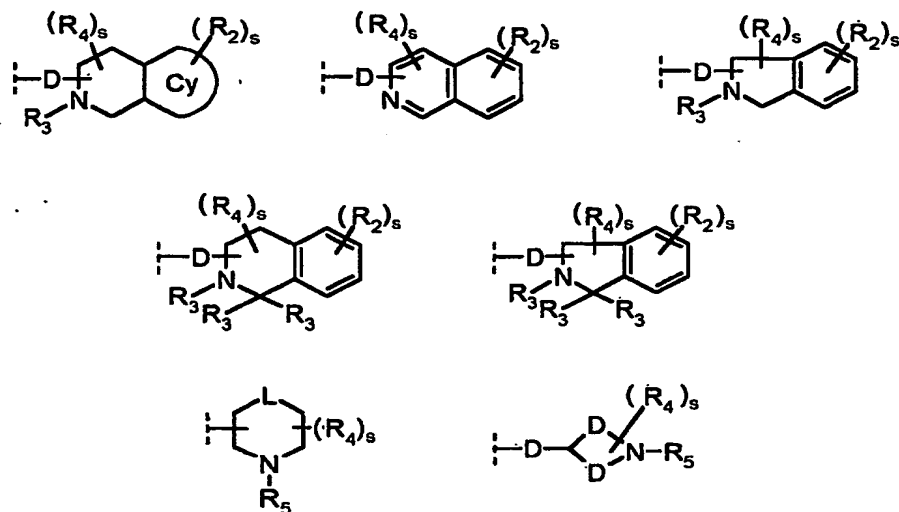
u is 0 - 2.

5. The compound according to claim 4, wherein

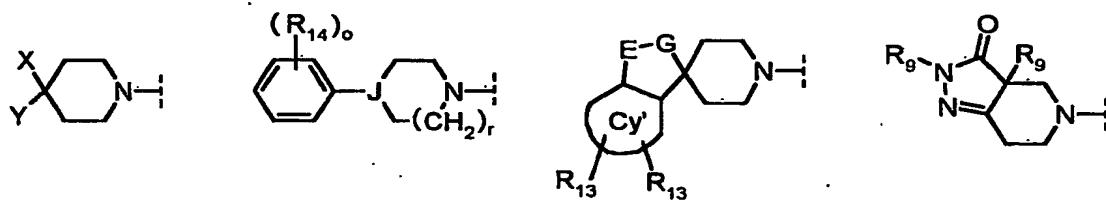
Ar is:

aryl which may be substituted with one to three substituents independently selected from the group consisting of cyano, perfluoroalkoxy, halo, alkyl, (D)-cycloalkyl, alkoxy and/or haloalkyl;

R_1 is:



A is:



R_2 is independently:

hydrogen,
halo,
alkyl,
haloalkyl,
alkoxy or
(D)-cycloalkyl;

R_3 is independently:

hydrogen or
alkyl;

R₄ is independently:

hydrogen,
alkyl,
(D)-aryl,
(D)-heteroaryl,
(D)-N(R₆)₂,
(D)-NR₆C(O)alkyl or
(D)-NR₆SO₂alkyl;

R₅ is independently:

hydrogen or
alkyl;

R₆ is independently:

hydrogen,
alkyl or
cycloalkyl;

R₉ is hydrogen or (D)-aryl;

R₁₀ is hydrogen or C₁ - C₄ alkyl;

R₁₁ is independently:

hydrogen or
alkyl;

R₁₂ is:

hydrogen or
alkyl;

R₁₃ is:

hydrogen,
halo,

alkyl,
alkoxy or
 $C\equiv N$;

R_{14} is independently:

hydrogen,
hydroxy,
cyano,
nitro,
halo,
alkyl,
alkoxy,
haloalkyl,
(D)- $N(R_{16})_2$,
(D)- $NR_{16}COR_{16}$,
(D)- $NR_{16}CON(R_{16})_2$,
(D)- $NR_{16}C(O)OR_{16}$,
(D)- $NR_{16}C(R_{16})=N(R_{16})$,
(D)- $NR_{16}C(=NR_{16})N(R_{16})_2$,
(D)- $NR_{16}SO_2R_{16}$ or
(D)- $NR_{16}SO_2N(R_{16})_2$;

R_{16} is:

hydrogen,
halo,
alkoxy,
alkyl or
phenyl;

Cy is aryl;

X is:

alkyl,
 (D)-cycloalkyl,
 (D)-aryl,
 (D)-heteroaryl,
 (D)-heterocyclyl,
 (D)-NHC(O)R₁₁,
 (D)-CON(R₁₁R₁₁) or
 (D)-CO₂R₁₁;

Y is:

hydrogen,
 alkyl,
 (D)-cycloalkyl,
 (D)-aryl,
 (D)-heterocyclyl or
 (D)-heteroaryl;

Cy' is benzene or pyridine;

D is a bond or C₁ - C₄ alkylene;

E is NSO₂R₁₀, CHN(Y)COR₁₂ or CHN(Y)SO₂R₁₂;

G is D or CH alkyl;

J is CH or N;

L is NR₅;

n is 0 or 1, unless m is 0, then n is 1;

m is 0 or 1, unless n is 0, then m is 1;

o is 0, 1 or 2;

r is 1;

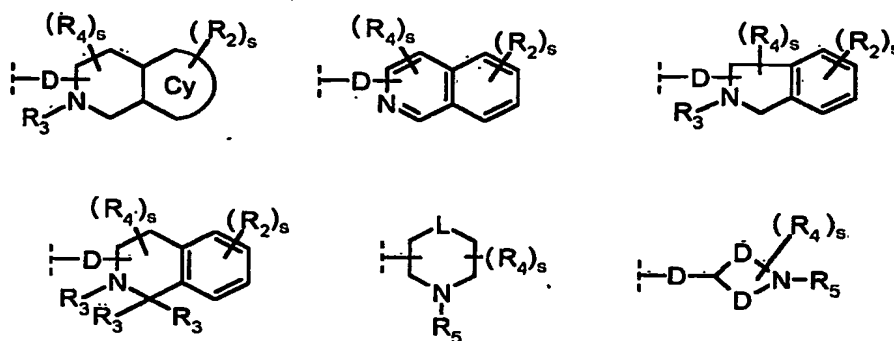
s is 0, 1, 2 or 3.

6. The compound according to claim 4 or 5, wherein

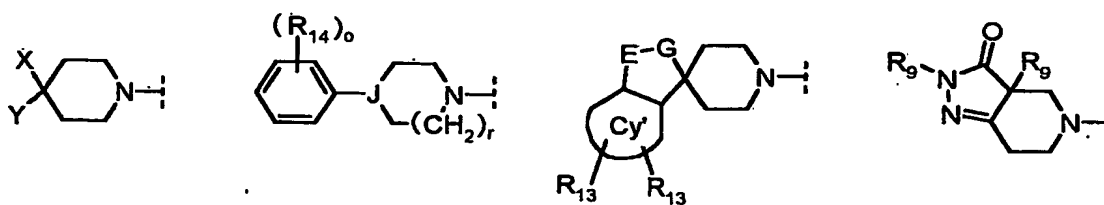
Ar is:

phenyl or naphthyl which may be substituted with one or two substituents independently selected from the group consisting of halo, alkyl, alkoxy and/or haloalkyl;

R₁ is:



A is:



R₂ is:

hydrogen,
halo or
alkyl;

R₄ is hydrogen;

R₅ is hydrogen;

R₉ is independently:

hydrogen or
(D)-aryl;

R₁₀ is independently:

hydrogen,
methyl or
ethyl;

R₁₁ is independently:

hydrogen or
C₁ - C₆ alkyl;

R₁₃ is:

hydrogen,
methyl or
ethyl;

R₁₄ is independently:

cyano,
nitro,
halo,
alkyl,
(D)-N(R₁₆)₂,
(D)-NR₁₆COR₁₆,
(D)-NR₁₆CON(R₁₆)₂,
(D)-NR₁₆C(O)OR₁₆ or
(D)-NR₁₆SO₂R₁₆;

Cy is aryl;

X is:

alkyl,
 (D)-cycloalkyl,
 (D)-heterocyclyl,
 (D)-NHC(O)R₁₁ or
 (D)-CON(R₁₁R₁₁);

Y is:

alkyl,
 (D)-cycloalkyl or
 (D)-heterocyclyl;

Cy' is benzene;

D is a bond or CH₂;

E is NSO₂R₁₀;

G is D;

J is CH or N;

L is NR₅;

n+m=1;

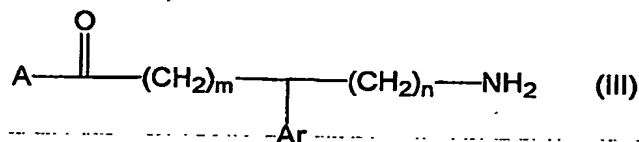
o is 1;

r is 1;

s is 0 or 1.

7. The compound of any of claims 1 to 6 for use as a medicament.

8. The intermediate compounds of the structural formula (III)



wherein A, Ar, m and n are as defined in claims 1 or 4

for use as a medicament.

9. Use of the compound of any of claims 1 to 6 for the preparation of a medicament for the treatment or prevention of disorders, diseases or conditions responsive to the inactivation or activation of the melanocortin-4 receptor in a mammal.
10. Use of the intermediate compounds of claim 8 for the treatment or prevention of disorders, diseases or conditions responsive to the inactivation or activation of the melanocortin-4 receptor in a mammal.
11. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of cancer cachexia.
12. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of muscle wasting.
13. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of anorexia.

14. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of anxiety and/or depression.
15. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of obesity.
16. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of diabetes mellitus.
17. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of male or female sexual dysfunction.
18. Use according to claims 9 and 10 for the preparation of a medicament for the treatment or prevention of erectile dysfunction.
19. A pharmaceutical composition which comprises a compound of any of claims 1 to 6 and a pharmaceutically acceptable carrier.
20. A pharmaceutical composition which comprises the intermediate compounds of claim 8 and a pharmaceutically acceptable carrier.

EPO - Munich
69
20. März 2003

ABSTRACT

The present invention relates to novel substituted piperidine and piperazine derivatives as melanocortin-4 receptor (MC-4R) modulators. MC-4R agonists of the invention can be used for the treatment of disorders and diseases such as obesity, diabetes, and sexual dysfunction, whereas the MC-4R antagonists are useful for the treatment of disorders and diseases such as cancer cachexia, muscle wasting, anorexia, anxiety and depression. All diseases and disorders where the regulation of the MC-4R is involved can be treated with the compounds of the invention.

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